

## Environmental Protection Agency

## § 86.010-18

section apply beginning with the 2010 model year.

*DTC* means diagnostic trouble code.

*Engine or engine system* as used in §§ 86.007-17, 86.007-30, 86.010-18, and 86.010-38 means the engine, fuel system, induction system, aftertreatment system, and everything that makes up the system for which an engine manufacturer has received a certificate of conformity.

*Engine start* as used in § 86.010-18 means the point when the engine reaches a speed 150 rpm below the normal, warmed-up idle speed (as determined in the drive position for vehicles equipped with an automatic transmission). For hybrid vehicles or for engines employing alternative engine start hardware or strategies (e.g., integrated starter and generators.), the manufacturer may use an alternative definition for engine start (e.g., key-on) provided the alternative definition is based on equivalence to an engine start for a conventional vehicle.

*Functional check*, in the context of onboard diagnostics, means verifying that a component and/or system that receives information from a control computer responds properly to a command from the control computer.

*Ignition cycle* as used in § 86.010-18 means a cycle that begins with engine start, meets the engine start definition for at least two seconds plus or minus one second, and ends with engine shut-off.

*Limp-home operation* as used in § 86.010-18 means an operating mode that an engine is designed to enter upon determining that normal operation cannot be maintained. In general, limp-home operation implies that a component or system is not operating properly or is believed to be not operating properly.

*Malfunction* means the conditions have been met that require the activation of an OBD malfunction indicator light and storage of a DTC.

*MIL-on DTC* means the diagnostic trouble code stored when an OBD system has detected and confirmed that a malfunction exists (e.g., typically on the second drive cycle during which a given OBD monitor has evaluated a system or component). Industry stand-

ards may refer to this as a confirmed or an active DTC.

*Onboard Diagnostics (OBD) group* means a combination of engines, engine families, or engine ratings that use the same OBD strategies and similar calibrations.

*Pending DTC* means the diagnostic trouble code stored upon the detection of a potential malfunction.

*Permanent DTC* means a DTC that corresponds to a MIL-on DTC and is stored in non-volatile random access memory (NVRAM). A permanent DTC can only be erased by the OBD system itself and cannot be erased through human interaction with the OBD system or any onboard computer.

*Potential malfunction* means that conditions have been detected that meet the OBD malfunction criteria but for which more drive cycles are allowed to provide further evaluation prior to confirming that a malfunction exists.

*Previous-MIL-on DTC* means a DTC that corresponds to a MIL-on DTC but is distinguished by representing a malfunction that the OBD system has determined no longer exists but for which insufficient operation has occurred to satisfy the DTC erasure provisions.

*Rationality check*, in the context of onboard diagnostics, means verifying that a component that provides input to a control computer provides an accurate input to the control computer while in the range of normal operation and when compared to all other available information.

*Similar conditions*, in the context of onboard diagnostics, means engine conditions having an engine speed within 375 rpm, load conditions within 20 percent, and the same warm up status (i.e., cold or hot). The manufacturer may use other definitions of similar conditions based on comparable timeliness and reliability in detecting similar engine operation.

[74 FR 8369, Feb. 24, 2009]

### **§ 86.010-18 On-board Diagnostics for engines used in applications greater than 14,000 pounds GVWR.**

(a) *General*. According to the implementation schedule shown in paragraph (o) of this section, heavy-duty engines intended for use in a heavy-duty vehicle weighing more than 14,000

pounds GVWR must be equipped with an on-board diagnostic (OBD) system capable of monitoring all emission-related engine systems or components during the life of the engine. The OBD system is required to detect all malfunctions specified in paragraphs (g), (h), and (i) of this § 86.010-18 although the OBD system is not required to use a unique monitor to detect each of those malfunctions.

(1) When the OBD system detects a malfunction, it must store a pending, a MIL-on, or a previous-MIL-on diagnostic trouble code (DTC) in the on-board computer's memory. A malfunction indicator light (MIL) must also be activated as specified in paragraph (b) of this section.

(2) *Data link connector.* (i) For model years 2010 through 2012, the OBD system must be equipped with a data link connector to provide access to the stored DTCs as specified in paragraph (k)(2) of this section.

(ii) For model years 2013 and later, the OBD system must be equipped with a standardized data link connector to provide access to the stored DTCs as specified in paragraph (k)(2) of this section.

(3) The OBD system cannot be programmed or otherwise designed to deactivate based on age and/or mileage. This requirement does not alter existing law and enforcement practice regarding a manufacturer's liability for an engine beyond its regulatory useful life, except where an engine has been programmed or otherwise designed so that an OBD system deactivates based on age and/or mileage of the engine.

(4) *Drive cycle or driving cycle*, in the context of this § 86.010-18, means operation that meets any of the conditions of paragraphs (a)(4)(i) through (a)(4)(iv) of this section. Further, for OBD monitors that run during engine-off conditions, the period of engine-off time following engine shutoff and up to the next engine start may be considered part of the drive cycle for the conditions of paragraphs (a)(4)(i) and (a)(4)(iv) of this section. For engines/vehicles that employ engine shutoff OBD monitoring strategies that do not require the vehicle operator to restart the engine to continue vehicle operation (e.g., a hybrid bus with engine

shutoff at idle), the manufacturer may use an alternative definition for drive cycle (e.g., key-on followed by key-off). Any alternative definition must be based on equivalence to engine startup and engine shutoff signaling the beginning and ending of a single driving event for a conventional vehicle. For engines that are not likely to be routinely operated for long continuous periods of time, a manufacturer may also request approval to use an alternative definition for drive cycle (e.g., solely based on engine start and engine shutoff without regard to four hours of continuous engine-on time). Administrator approval of the alternative definition will be based on manufacturer-submitted data and/or information demonstrating the typical usage, operating habits, and/or driving patterns of these vehicles.

(i) Begins with engine start and ends with engine shutoff;

(ii) Begins with engine start and ends after four hours of continuous engine-on operation;

(iii) Begins at the end of the previous four hours of continuous engine-on operation and ends after four hours of continuous engine-on operation; or

(iv) Begins at the end of the previous four hours of continuous engine-on operation and ends with engine shutoff.

(5) As an alternative to demonstrating compliance with the provisions of paragraphs (b) through (l) of this § 86.010-18, a manufacturer may demonstrate how the OBD system they have designed to comply with California OBD requirements for engines used in applications greater than 14,000 pounds also complies with the intent of the provisions of paragraphs (b) through (l) of this section. To make use of this alternative, the manufacturer must demonstrate to the Administrator how the OBD system they intend to certify meets the intent behind all of the requirements of this section, where applicable (e.g., paragraph (h) of this section would not apply for a diesel fueled/CI engine). Furthermore, if making use of this alternative, the manufacturer must comply with the specific certification documentation requirements of paragraph (m)(3) of this section.

(6) *Temporary provisions to address hardship due to unusual circumstances.*

(i) After considering the unusual circumstances, the Administrator may permit the manufacturer to introduce into U.S. commerce engines that do not comply with this § 86.010-18 for a limited time if all the following conditions apply:

(A) Unusual circumstances that are clearly outside the manufacturer's control prevent compliance with the requirements of this § 86.010-18.

(B) The manufacturer exercised prudent planning and was not able to avoid the violation and has taken all reasonable steps to minimize the extent of the nonconformity.

(C) No other allowances are available under the regulations in this chapter to avoid the impending violation.

(ii) To apply for an exemption, the manufacturer must send to the Administrator a written request as soon as possible before being in violation. In the request, the manufacturer must show that all the conditions and requirements of paragraph (a)(6)(i) of this section are met.

(iii) The request must also include a plan showing how all the applicable requirements will be met as quickly as possible.

(iv) The manufacturer shall give the Administrator other relevant information upon request.

(v) The Administrator may include additional conditions on an approval granted under the provisions of this paragraph (a)(6), including provisions that may require field repair at the manufacturer's expense to correct the noncompliance.

(vi) Engines sold as non-compliant under this temporary hardship provision must display "non-OBD" in the data stream as required under paragraph (k)(4)(ii) of this section. Upon correcting the noncompliance, the data stream value must be updated accordingly.

(b) *Malfunction indicator light (MIL) and Diagnostic Trouble Codes (DTC).* The OBD system must incorporate a malfunction indicator light (MIL) or equivalent and must store specific types of diagnostic trouble codes (DTC). Unless otherwise specified, all provisions of

this paragraph (b) apply for 2010 and later model years.

(1) *MIL specifications.* (i) For model years 2013 and later, the MIL must be located on the primary driver's side instrument panel and be of sufficient illumination and location to be readily visible under all lighting conditions. The MIL must be amber (yellow) in color; the use of red for the OBD-related MIL is prohibited. More than one general purpose malfunction indicator light for emission-related problems shall not be used; separate specific purpose warning lights (e.g., brake system, fasten seat belt, oil pressure, etc.) are permitted. When activated, the MIL shall display the International Standards Organization (ISO) engine symbol.

(ii) The OBD system must activate the MIL when the ignition is in the key-on/engine-off position before engine cranking to indicate that the MIL is functional. The MIL shall be activated continuously during this functional check for a minimum of 5 seconds. During this MIL key-on functional check, the data stream value (see paragraph (k)(4)(ii) of this section) for MIL status must indicate "commanded off" unless the OBD system has detected a malfunction and has stored a MIL-on DTC. This MIL key-on functional check is not required during vehicle operation in the key-on/engine-off position subsequent to the initial engine cranking of an ignition cycle (e.g., due to an engine stall or other non-commanded engine shutoff).

(iii) As an option, the MIL may be used to indicate readiness status (see paragraph (k)(4)(i) of this section) in a standardized format in the key-on/engine-off position.

(iv) A manufacturer may also use the MIL to indicate which, if any, DTCs are currently stored (e.g., to "blink" the stored DTCs). Such use must not activate unintentionally during routine driver operation.

(v) For model years 2013 and later, the MIL required by this paragraph (b) must not be used in any other way than is specified in this section.

(2) *MIL activation and DTC storage protocol.* (i) Within 10 seconds of detecting a potential malfunction, the OBD system must store a pending DTC that identifies the potential malfunction.

(ii) If the potential malfunction is again detected before the end of the next drive cycle during which monitoring occurs (i.e., the potential malfunction has been confirmed as a malfunction), then within 10 seconds of such detection the OBD system must activate the MIL continuously and store a MIL-on DTC (systems using the SAE J1939 standard protocol specified in paragraph (k)(1) of this section may either erase or retain the pending DTC in conjunction with storing the MIL-on DTC). If the potential malfunction is not detected before the end of the next drive cycle during which monitoring occurs (i.e., there is no indication of the malfunction at any time during the drive cycle), the corresponding pending DTC should be erased at the end of the drive cycle. Similarly, if a malfunction is detected for the first time and confirmed on a given drive cycle without need for further evaluation, then within 10 seconds of such detection the OBD system must activate the MIL continuously and store a MIL-on DTC (again, systems using the SAE J1939 standard protocol specified in paragraph (k)(1) of this section may optionally store a pending DTC in conjunction with storing the MIL-on DTC).

(iii) A manufacturer may request Administrator approval to employ alternative statistical MIL activation and DTC storage protocols to those specified in paragraphs (b)(2)(i) and (b)(2)(ii) of this section. Approval will depend upon the manufacturer providing data and/or engineering evaluations that demonstrate that the alternative protocols can evaluate system performance and detect malfunctions in a manner that is equally effective and timely. Strategies requiring on average more than six drive cycles for MIL activation will not be accepted.

(iv) The OBD system must store a “freeze frame” of the operating conditions (as defined in paragraph (k)(4)(iii) of this section) present upon detecting a malfunction or a potential malfunction. In the event that a pending DTC has matured to a MIL-on DTC, the manufacturer shall either retain the currently stored freeze frame conditions or replace the stored freeze frame with freeze frame conditions regarding the MIL-on DTC. Any freeze frame

stored in conjunction with any pending DTC or MIL-on DTC should be erased upon erasure of the corresponding DTC.

(v) If the engine enters a limp-home mode of operation that can affect emissions or the performance of the OBD system, or in the event of a malfunction of an onboard computer(s) itself that can affect the performance of the OBD system, the OBD system must activate the MIL and store a MIL-on DTC within 10 seconds to inform the vehicle operator. If the limp-home mode of operation is recoverable (i.e., operation automatically returns to normal at the beginning of the following ignition cycle), the OBD system may wait to activate the MIL and store the MIL-on DTC if the limp-home mode of operation is again entered before the end of the next ignition cycle rather than activating the MIL within 10 seconds on the first drive cycle during which the limp-home mode of operation is entered.

(vi) Before the end of an ignition cycle, the OBD system must store a permanent DTC(s) that corresponds to any stored MIL-on DTC(s).

(3) *MIL deactivation and DTC erasure protocol*—(i) *Deactivating the MIL*. Except as otherwise provided for in paragraphs (g)(2)(iv)(E) and (g)(6)(iv)(B) of this section for diesel misfire malfunctions and empty reductant tanks, and paragraphs (h)(1)(iv)(F), (h)(2)(viii), and (h)(7)(iv)(B) of this section for gasoline fuel system, misfire, and evaporative system malfunctions, once the MIL has been activated, it may be deactivated after three subsequent sequential drive cycles during which the monitoring system responsible for activating the MIL functions and the previously detected malfunction is no longer present and provided no other malfunction has been detected that would independently activate the MIL according to the requirements outlined in paragraph (b)(2) of this section.

(ii) *Erasing a MIL-on DTC*. The OBD system may erase a MIL-on DTC if the identified malfunction has not again been detected in at least 40 engine warm up cycles and the MIL is presently not activated for that malfunction. The OBD system may also erase a MIL-on DTC upon deactivating the MIL according to paragraph (b)(3)(i) of

this section provided a previous-MIL-on DTC is stored upon erasure of the MIL-on DTC. The OBD system may erase a previous-MIL-on DTC if the identified malfunction has not again been detected in at least 40 engine warm up cycles and the MIL is presently not activated for that malfunction.

(iii) *Erasing a permanent DTC.* The OBD system can erase a permanent DTC only if:

(A) The OBD system itself determines that the malfunction that caused the corresponding permanent DTC to be stored is no longer present and is not commanding activation of the MIL, concurrent with the requirements of paragraph (b)(3)(i) of this section which, for purposes of this paragraph (b)(3)(iii), shall apply to all monitors.

(B) All externally erasable DTC information stored in the onboard computer has been erased (i.e., through the use of a scan tool or battery disconnect) and the monitor of the malfunction that caused the permanent DTC to be stored is subject to the minimum ratio requirements of paragraph (d) of this section, the OBD system shall erase the permanent DTC at the end of a drive cycle if the monitor has run and made one or more determinations during a drive cycle that the malfunction of the component or the system is not present and has not made any determinations within the same drive cycle that the malfunction is present.

(C)(1) All externally erasable DTC information stored in the onboard computer has been erased (i.e., through the use of a scan tool or battery disconnect) and the monitor of the malfunction that caused the permanent DTC to be stored is not subject to the minimum ratio requirements of paragraph (d) of this section, the OBD system shall erase the permanent DTC at the end of a drive cycle provided the following two criteria have independently been satisfied:

(i) The monitor has run and made one or more determinations during a drive cycle that the malfunction is no longer present and has not made any determinations within the same drive cycle that the malfunction is present; and,

(ii) The monitor does not detect a malfunction on a drive cycle and the criteria of paragraph (d)(4)(ii) of this section has been met.

(2) These two separate criteria may be met on the same or different drive cycles provided the monitor never detects a malfunction during either drive cycle, and if criteria (b)(3)(iii)(C)(I)(i) happens first then no malfunction may be detected before criteria (b)(3)(iii)(C)(I)(ii) occurs. If a malfunction occurs after criteria (b)(3)(iii)(C)(I)(i) then criteria (b)(3)(iii)(C)(I)(i) must be satisfied again. For the second criterion, the manufacturer must exclude any temperature and/or elevation provisions of paragraph (d)(4)(ii) of this section. For this paragraph (b)(3)(iii)(C), monitors required to use "similar conditions" as defined in § 86.010-2 to store and erase pending and MIL-on DTCs cannot require that the similar conditions be met prior to erasure of the permanent DTC.

(D) The Administrator shall allow monitors subject to paragraph (b)(3)(iii)(B) of this section to use the criteria of paragraph (b)(3)(iii)(C) of this section in lieu of paragraph (b)(3)(iii)(B). Further, manufacturers may request Administrator approval to use alternative criteria to erase the permanent DTC. The Administrator shall approve alternate criteria that will not likely require driving conditions that are longer and more difficult to meet than those required under paragraph (b)(3)(iii)(C) of this section and do not require access to enhanced scan tools to determine conditions necessary to erase the permanent DTC.

(4) *Exceptions to MIL and DTC requirements.* (i) If a limp-home mode of operation causes a overt indication (e.g., activation of a red engine shut-down warning light) such that the driver is certain to respond and have the problem corrected, a manufacturer may choose not to activate the MIL as required by paragraph (b)(2)(v) of this section. Additionally, if an auxiliary emission control device has been properly activated as approved by the Administrator, a manufacturer may choose not to activate the MIL.

(ii) For gasoline engines, a manufacturer may choose to meet the MIL and

DTC requirements in § 86.007–17 in lieu of meeting the requirements of paragraph (b) of this § 86.010–18.

(c) *Monitoring conditions.* The OBD system must monitor and detect the malfunctions specified in paragraphs (g), (h), and (i) of this section under the following general monitoring conditions. The more specific monitoring conditions of paragraph (d) of this section are sometimes required according to the provisions of paragraphs (g), (h), and (i) of this section.

(1) As specifically provided for in paragraphs (g), (h), and (i) of this section, the monitoring conditions for detecting malfunctions must be technically necessary to ensure robust detection of malfunctions (e.g., avoid false passes and false indications of malfunctions); designed to ensure monitoring will occur under conditions that may reasonably be expected to be encountered in normal vehicle operation and normal vehicle use; and, designed to ensure monitoring will occur during the FTP transient test cycle contained in appendix I paragraph (f), of this part, or similar drive cycle as approved by the Administrator.

(2) Monitoring must occur at least once per drive cycle in which the monitoring conditions are met.

(3) Manufacturers may define monitoring conditions that are not encountered during the FTP cycle as required in paragraph (c)(1) of this section. In doing so, the manufacturer would be expected to consider the degree to which the requirement to run during the FTP transient cycle restricts monitoring during in-use operation, the technical necessity for defining monitoring conditions that are not encountered during the FTP cycle, whether monitoring is otherwise not feasible during the FTP cycle, and/or the ability to demonstrate that the monitoring conditions satisfy the minimum acceptable in-use monitor performance ratio requirement as defined in paragraph (d) of this section.

(d) *In-use performance tracking.* As specifically required in paragraphs (g), (h), and (i) of this section, the OBD system must monitor and detect the malfunctions specified in paragraphs (g), (h), and (i) of this section according to the criteria of this paragraph (d). The

OBD system is not required to track and report in-use performance for monitors other than those specifically identified in paragraph (d)(1) of this section, but all monitors on applicable model year engines are still required to meet the in-use performance ratio as specified in paragraph (d)(1)(ii) of this section.

(1) The manufacturer must implement software algorithms in the OBD system to individually track and report the in-use performance of the following monitors, if equipped, in the standardized format specified in paragraph (e) of this section: NMHC converting catalyst (paragraph (g)(5) of this section); NO<sub>x</sub> converting catalyst (paragraph (g)(6) of this section); gasoline catalyst (paragraph (h)(6) of this section); exhaust gas sensor (paragraph (g)(9) of this section) or paragraph (h)(8) of this section; evaporative system (paragraph (h)(7) of this section); EGR system (paragraph (g)(3) of this section or (h)(3) of this section); VVT system (paragraph (g)(10) of this section or (h)(9) of this section); secondary air system (paragraph (h)(5) of this section); DPF system (paragraph (g)(8) of this section); boost pressure control system (paragraph (g)(4) of this section); and, NO<sub>x</sub> adsorber system (paragraph (g)(7) of this section).

(i) The manufacturer shall not use the calculated ratio specified in paragraph (d)(2) of this section or any other indication of monitor frequency as a monitoring condition for a monitor (e.g., using a low ratio to enable more frequent monitoring through diagnostic executive priority or modification of other monitoring conditions, or using a high ratio to enable less frequent monitoring).

(ii) For model years 2013 and later, manufacturers must define monitoring conditions that, in addition to meeting the criteria in paragraphs (c)(1) and (d)(1) of this section, ensure that the monitor yields an in-use performance ratio (as defined in paragraph (d)(2) of this section) that meets or exceeds the minimum acceptable in-use monitor performance ratio of 0.100 for all monitors specifically required in paragraphs (g), (h), and (i) of this section to meet the monitoring condition requirements of this paragraph (d).

(iii) If the most reliable monitoring method developed requires a lower ratio for a specific monitor than that specified in paragraph (d)(1)(ii) of this section, the Administrator may lower the minimum acceptable in-use monitoring performance ratio.

(2) *In-use performance ratio definition.* For monitors required to meet the requirements of paragraph (d) of this section, the performance ratio must be calculated in accordance with the specifications of this paragraph (d)(2).

(i) The numerator of the performance ratio is defined as the number of times a vehicle has been operated such that all monitoring conditions have been encountered that are necessary for the specific monitor to detect a malfunction.

(ii) The denominator is defined as the number of times a vehicle has been operated in accordance with the provisions of paragraph (d)(4) of this section.

(iii) The performance ratio is defined as the numerator divided by the denominator.

(3) *Specifications for incrementing the numerator.* (i) Except as provided in paragraph (d)(3)(v) of this section, the numerator, when incremented, must be incremented by an integer of one. The numerator shall not be incremented more than once per drive cycle.

(ii) The numerator for a specific monitor must be incremented within 10 seconds if and only if the following criteria are satisfied on a single drive cycle:

(A) Every monitoring condition has been satisfied that is necessary for the specific monitor to detect a malfunction and store a pending DTC, including applicable enable criteria, presence or absence of related DTCs, sufficient length of monitoring time, and diagnostic executive priority assignments (e.g., diagnostic "A" must execute prior to diagnostic "B"). For the purpose of incrementing the numerator, satisfying all the monitoring conditions necessary for a monitor to determine that the monitor is not malfunctioning shall not, by itself, be sufficient to meet this criteria.

(B) For monitors that require multiple stages or events in a single drive cycle to detect a malfunction, every

monitoring condition necessary for all events to complete must be satisfied.

(C) For monitors that require intrusive operation of components to detect a malfunction, a manufacturer must request approval of the strategy used to determine that, had a malfunction been present, the monitor would have detected the malfunction. Administrator approval of the request will be based on the equivalence of the strategy to actual intrusive operation and the ability of the strategy to determine accurately if every monitoring condition was satisfied that was necessary for the intrusive event to occur.

(D) For the secondary air system monitor, the criteria in paragraphs (d)(3)(ii)(A) through (d)(3)(ii)(C) of this section are satisfied during normal operation of the secondary air system. Monitoring during intrusive operation of the secondary air system later in the same drive cycle for the sole purpose of monitoring shall not, by itself, be sufficient to meet these criteria.

(iii) For monitors that can generate results in a "gray zone" or "non-detection zone" (i.e., monitor results that indicate neither a properly operating system nor a malfunctioning system) or in a "non-decision zone" (e.g., monitors that increment and decrement counters until a pass or fail threshold is reached), the numerator, in general, shall not be incremented when the monitor indicates a result in the "non-detection zone" or prior to the monitor reaching a complete decision. When necessary, the Administrator will consider data and/or engineering analyses submitted by the manufacturer demonstrating the expected frequency of results in the "non-detection zone" and the ability of the monitor to determine accurately, had an actual malfunction been present, whether or not the monitor would have detected a malfunction instead of a result in the "non-detection zone."

(iv) For monitors that run or complete their evaluation with the engine off, the numerator must be incremented either within 10 seconds of the monitor completing its evaluation in the engine off state, or during the first 10 seconds of engine start on the subsequent drive cycle.

(v) Manufacturers that use alternative statistical MIL activation protocols as allowed in paragraph (b)(2)(iii) of this section for any of the monitors requiring a numerator, are required to increment the numerator(s) appropriately. The manufacturer may be required to provide supporting data and/or engineering analyses demonstrating both the equivalence of their incrementing approach to the incrementing specified in this paragraph (d)(3) for monitors using the standard MIL activation protocol, and the overall equivalence of the incrementing approach in determining that the minimum acceptable in-use performance ratio of paragraph (d)(1)(ii) of this section, if applicable, has been satisfied.

(4) *Specifications for incrementing the denominator.* (i) The denominator, when incremented, must be incremented by an integer of one. The denominator shall not be incremented more than once per drive cycle.

(ii) The denominator for each monitor must be incremented within 10 seconds if and only if the following criteria are satisfied on a single drive cycle:

(A) Cumulative time since the start of the drive cycle is greater than or equal to 600 seconds while at an elevation of less than 8,000 feet (2,400 meters) above sea level and at an ambient temperature of greater than or equal to 20 degrees Fahrenheit ( $-7^{\circ}\text{C}$ );

(B) Cumulative gasoline engine operation at or above 25 miles per hour or diesel engine operation at or above 1,150 rotations per minute (diesel engines may use the gasoline criterion for 2010 through 2012 model years), either of which occurs for greater than or equal to 300 seconds while at an elevation of less than 8,000 feet (2,400 meters) above sea level and at an ambient temperature of greater than or equal to 20 degrees Fahrenheit ( $-7^{\circ}\text{C}$ ); and,

(C) Continuous engine operation at idle (e.g., accelerator pedal released by driver and engine speed less than or equal to 200 rpm above normal warmed-up idle (as determined in the drive position for vehicles equipped with an automatic transmission) or vehicle speed less than or equal to one mile per hour) for greater than or equal to 30 seconds while at an elevation of less

than 8,000 feet (2,400 meters) above sea level and at an ambient temperature of greater than or equal to 20 degrees Fahrenheit ( $-7^{\circ}\text{C}$ ).

(iii) In addition to the requirements of paragraph (d)(4)(ii) of this section, the evaporative system monitor denominator(s) may be incremented if and only if:

(A) Cumulative time since the start of the drive cycle is greater than or equal to 600 seconds while at an ambient temperature of greater than or equal to 40 degrees Fahrenheit ( $4^{\circ}\text{C}$ ) but less than or equal to 95 degrees Fahrenheit ( $35^{\circ}\text{C}$ ); and,

(B) Engine cold start occurs with the engine coolant temperature greater than or equal to 40 degrees Fahrenheit ( $4^{\circ}\text{C}$ ) but less than or equal to 95 degrees Fahrenheit ( $35^{\circ}\text{C}$ ) and less than or equal to 12 degrees Fahrenheit ( $7^{\circ}\text{C}$ ) higher than the ambient temperature.

(iv) In addition to the requirements of paragraph (d)(4)(ii) of this section, the denominator(s) for the following monitors may be incremented if and only if the component or strategy is commanded "on" for a cumulative time greater than or equal to 10 seconds. For purposes of determining this commanded "on" time, the OBD system shall not include time during intrusive operation of any of the components or strategies that occurs later in the same drive cycle for the sole purpose of monitoring.

(A) Secondary air system (paragraph (h)(5) of this section).

(B) Cold start emission reduction strategy (paragraph (h)(4) of this section).

(C) Components or systems that operate only at engine start-up (e.g., glow plugs, intake air heaters) and are subject to monitoring under "other emission control systems" (paragraph (i)(4) of this section) or comprehensive component output components (paragraph (i)(3)(iii) of this section).

(v) In addition to the requirements of paragraph (d)(4)(ii) of this section, the denominator(s) for the following monitors of output components (except those operated only at engine start-up and subject to the requirements of paragraph (d)(4)(iv) of this section, may be incremented if and only if the component is commanded to function



(e.g., commanded “on”, “opened”, “closed”, “locked”) on two or more occasions during the drive cycle or for a cumulative time greater than or equal to 10 seconds, whichever occurs first:

(A) Variable valve timing and/or control system (paragraph (g)(10) of this section or (h)(9) of this section).

(B) “Other emission control systems” (paragraph (i)(4) of this section).

(C) Comprehensive component output component (paragraph (i)(3) of this section) (e.g., turbocharger waste-gates, variable length manifold runners).

(vi) For monitors of the following components, the manufacturer may use alternative or additional criteria for incrementing the denominator to that set forth in paragraph (d)(4)(ii) of this section. To do so, the alternative criteria must be based on equivalence to the criteria of paragraph (d)(4)(ii) of this section in measuring the frequency of monitor operation relative to the amount of engine operation:

(A) Engine cooling system input components (paragraph (i)(1) of this section).

(B) “Other emission control systems” (paragraph (i)(4) of this section).

(C) Comprehensive component input components that require extended monitoring evaluation (paragraph (i)(3) of this section) (e.g., stuck fuel level sensor rationality).

(D) Comprehensive component input component temperature sensor rationality monitors (paragraph (i)(3) of this section) (e.g., intake air temperature sensor, ambient temperature sensor, fuel temperature sensor).

(E) Diesel particulate filter (DPF) frequent regeneration (paragraph (g)(8)(ii)(B) of this section).

(vii) For monitors of the following components or other emission controls that experience infrequent regeneration events, the manufacturer may use alternative or additional criteria for incrementing the denominator to that set forth in paragraph (d)(4)(ii) of this section. To do so, the alternative criteria must be based on equivalence to the criteria of paragraph (d)(4)(ii) of this section in measuring the frequency of monitor operation relative to the amount of engine operation:

(A) NMHC converting catalyst (paragraph (g)(5) of this section).

(B) Diesel particulate filter (DPF) (paragraphs (g)(8)(ii)(A) and (g)(8)(ii)(D) of this section).

(viii) In addition to the requirements of paragraph (d)(4)(ii) of this section, the denominator(s) for the following monitors shall be incremented if and only if a regeneration event is commanded for a time greater than or equal to 10 seconds:

(A) DPF incomplete regeneration (paragraph (g)(8)(ii)(C) of this section).

(B) DPF active/intrusive injection (paragraph (g)(8)(ii)(E) of this section).

(ix) For hybrids that employ alternative engine start hardware or strategies (e.g., integrated starter and generators), or alternative fuel vehicles (e.g., dedicated, bi-fuel, or dual-fuel applications), the manufacturer may use alternative criteria for incrementing the denominator to that set forth in paragraph (d)(4)(ii) of this section. In general, the Administrator will not approve alternative criteria for those hybrids that employ engine shut off only at or near idle and/or vehicle stop conditions. To use alternative criteria, the alternative criteria must be based on the equivalence to the criteria of paragraph (d)(4)(ii) of this section in measuring the amount of vehicle operation relative to the measure of conventional vehicle operation.

(5) *Disabling of numerators and denominators.* (i) Within 10 seconds of detecting a malfunction (i.e., a pending or a MIL-on DTC has been stored) that disables a monitor for which the monitoring conditions in paragraph (d) of this section must be met, the OBD system must stop incrementing the numerator and denominator for any monitor that may be disabled as a consequence of the detected malfunction. Within 10 seconds of the time at which the malfunction is no longer being detected (e.g., the pending DTC is erased through OBD system self-clearing or through a scan tool command), incrementing of all applicable numerators and denominators must resume.

(ii) Within 10 seconds of the start of a power take-off unit (e.g., dump bed, snow plow blade, or aerial bucket, etc.) that disables a monitor for which the monitoring conditions in paragraph (d) of this section must be met, the OBD

system must stop incrementing the numerator and denominator for any monitor that may be disabled as a consequence of power take-off operation. Within 10 seconds of the time at which the power take-off operation ends, incrementing of all applicable numerators and denominators must resume.

(iii) Within 10 seconds of detecting a malfunction (i.e., a pending or a MIL-on DTC has been stored) of any component used to determine if the criteria of paragraphs (d)(4)(ii) and (d)(4)(iii) of this section are satisfied, the OBD system must stop incrementing all applicable numerators and denominators. Within 10 seconds of the time at which the malfunction is no longer being detected (e.g., the pending DTC is erased through OBD system self-clearing or through a scan tool command), incrementing of all applicable numerators and denominators must resume.

(e) *Standardized tracking and reporting of in-use monitor performance*—(1) *General*. For monitors required to track and report in-use monitor performance according to paragraph (d) of this section, the performance data must be tracked and reported in accordance with the specifications in paragraphs (d)(2), (e), and (k)(5) of this section. The OBD system must separately report an in-use monitor performance numerator and denominator for each of the following components:

(i) For diesel engines, NMHC catalyst bank 1, NMHC catalyst bank 2, NO<sub>x</sub> catalyst bank 1, NO<sub>x</sub> catalyst bank 2, exhaust gas sensor bank 1, exhaust gas sensor bank 2, EGR/VVT system, DPF, boost pressure control system, and NO<sub>x</sub> adsorber. The OBD system must also report a general denominator and an ignition cycle counter in the standardized format specified in paragraphs (e)(5), (e)(6), and (k)(5) of this section.

(ii) For gasoline engines, catalyst bank 1, catalyst bank 2, exhaust gas sensor bank 1, exhaust gas sensor bank 2, evaporative leak detection system, EGR/VVT system, and secondary air system. The OBD system must also report a general denominator and an ignition cycle counter in the standardized format specified in paragraphs (e)(5), (e)(6), and (k)(5) of this section.

(iii) For specific components or systems that have multiple monitors that

are required to be reported under paragraphs (g) and (h) of this section (e.g., exhaust gas sensor bank 1 may have multiple monitors for sensor response or other sensor characteristics), the OBD system must separately track numerators and denominators for each of the specific monitors and report only the corresponding numerator and denominator for the specific monitor that has the lowest numerical ratio. If two or more specific monitors have identical ratios, the corresponding numerator and denominator for the specific monitor that has the highest denominator must be reported for the specific component.

(2) *Numerator*. (i) The OBD system must report a separate numerator for each of the applicable components listed in paragraph (e)(1) of this section.

(ii) The numerator(s) must be reported in accordance with the specifications in paragraph (k)(5)(ii) of this section.

(3) *Denominator*. (i) The OBD system must report a separate denominator for each of the applicable components listed in paragraph (e)(1) of this section.

(ii) The denominator(s) must be reported in accordance with the specifications in paragraph (k)(5)(ii) of this section.

(4) *Monitor performance ratio*. For purposes of determining which corresponding numerator and denominator to report as required in paragraph (e)(1)(iii) of this section, the ratio must be calculated in accordance with the specifications in paragraph (k)(5)(iii) of this section.

(5) *Ignition cycle counter*. (i) The ignition cycle counter is defined as a counter that indicates the number of ignition cycles a vehicle has experienced according to the specifications of paragraph (e)(5)(ii)(B) of this section. The ignition cycle counter must be reported in accordance with the specifications in paragraph (k)(5)(ii) of this section.

(ii) The ignition cycle counter must be incremented as follows:

(A) The ignition cycle counter, when incremented, must be incremented by an integer of one. The ignition cycle counter shall not be incremented more than once per ignition cycle.

(B) The ignition cycle counter must be incremented within 10 seconds if and only if the engine exceeds an engine speed of 50 to 150 rpm below the normal, warmed-up idle speed (as determined in the drive position for engines paired with an automatic transmission) for at least two seconds plus or minus one second.

(iii) Within 10 seconds of detecting a malfunction (i.e., a pending or a MIL-on DTC has been stored) of any component used to determine if the criteria in paragraph (e)(5)(ii)(B) of this section are satisfied (i.e., engine speed or time of operation), the OBD system must stop incrementing the ignition cycle counter. Incrementing of the ignition cycle counter shall not be stopped for any other condition. Within 10 seconds of the time at which the malfunction is no longer being detected (e.g., the pending DTC is erased through OBD system self-clearing or through a scan tool command), incrementing of the ignition cycle counter must resume.

(6) *General denominator.* (i) The general denominator is defined as a measure of the number of times an engine has been operated according to the specifications of paragraph (e)(6)(ii)(B) of this section. The general denominator must be reported in accordance with the specifications in paragraph (k)(5)(ii) of this section.

(ii) The general denominator must be incremented as follows:

(A) The general denominator, when incremented, must be incremented by an integer of one. The general denominator shall not be incremented more than once per drive cycle.

(B) The general denominator must be incremented within 10 seconds if and only if the criteria identified in paragraph (d)(4)(ii) of this section are satisfied on a single drive cycle.

(C) Within 10 seconds of detecting a malfunction (i.e., a pending or a MIL-on DTC has been stored) of any component used to determine if the criteria in paragraph (d)(4)(ii) of this section are satisfied (i.e., vehicle speed/load, ambient temperature, elevation, idle operation, or time of operation), the OBD system must stop incrementing the general denominator. Incrementing of the general denominator shall not be stopped for any other condition (e.g.,

the disablement criteria in paragraphs (d)(5)(i) and (d)(5)(ii) of this section shall not disable the general denominator). Within 10 seconds of the time at which the malfunction is no longer being detected (e.g., the pending DTC is erased through OBD system self-clearing or through a scan tool command), incrementing of the general denominator must resume.

(f) *Malfunction criteria determination.*

(1) In determining the malfunction criteria for the diesel engine monitors required under paragraphs (g) and (i) of this section that are required to indicate a malfunction before emissions exceed an emission threshold based on any applicable standard, the manufacturer must:

(i) Use the emission test cycle and standard (i.e., the transient FTP or the supplemental emissions test (SET)) determined by the manufacturer to provide the most effective monitoring conditions and robust monitor provided all other applicable requirements of this section are met.

(ii) Identify in the certification documentation required under paragraph (m) of this section, the test cycle and standard determined by the manufacturer to be the most stringent for each applicable monitor and the most effective and robust for each applicable monitor.

(iii) If the Administrator reasonably believes that a manufacturer has determined incorrectly the test cycle and standard that is most stringent or effective, the manufacturer must be able to provide emission data and/or engineering analysis supporting their choice of test cycle and standard.

(2) On engines equipped with emission controls that experience infrequent regeneration events, a manufacturer need not adjust the emission test results that are used to determine the malfunction criteria for monitors that are required to indicate a malfunction before emissions exceed a certain emission threshold. For each such monitor, should the manufacturer choose to adjust the emission test results, the manufacturer must adjust the emission result as done in accordance with the provisions of § 86.004-28(i) with the component for which the malfunction criteria are being established having been

deteriorated to the malfunction threshold. The adjusted emission value must be used for purposes of determining whether or not the applicable emission threshold is exceeded.

(i) For purposes of this paragraph (f)(2), regeneration means an event, by design, during which emissions levels change while the emission control performance is being restored.

(ii) For purposes of this paragraph (f)(2), infrequent means having an expected frequency of less than once per transient FTP cycle.

(3) For gasoline engines, rather than meeting the malfunction criteria speci-

fied under paragraphs (h) and (i) of this section, the manufacturer may request approval to use an OBD system certified to the requirements of § 86.007–17. To do so, the manufacturer must demonstrate use of good engineering judgment in determining equivalent malfunction detection criteria to those required in this section.

(g) *OBD monitoring requirements for diesel-fueled/compression-ignition engines.* The following table shows the thresholds at which point certain components or systems, as specified in this paragraph (g), are considered malfunctioning.

TABLE 1—OBD EMISSIONS THRESHOLDS FOR DIESEL-FUELED/COMPRESSION-IGNITION ENGINES MEANT FOR PLACEMENT IN APPLICATIONS GREATER THAN 14,000 POUNDS GVWR (G/BHP-HR)

Component	§ 86.010–18 reference	NMHC	CO	NO <sub>x</sub>	PM
Model years 2010–2012:					
NO <sub>x</sub> aftertreatment system .....	(g)(6) (g)(7)			+0.6	
Diesel particulate filter (DPF) system .....	(g)(8)	2.5x			0.05/+0.04
Air-fuel ratio sensors upstream of aftertreatment devices .....	(g)(9)	2.5x	2.5x	+0.3	0.03/+0.02
Air-fuel ratio sensors downstream of aftertreatment devices .....	(g)(9)	2.5x		+0.3	0.05/+0.04
NO <sub>x</sub> sensors .....	(g)(9)			+0.6	0.05/+0.04
“Other monitors” with emissions thresholds .....	(g)(1) (g)(3) (g)(4) (g)(10)	2.5x	2.5x	+0.3	0.03/+0.02
Model years 2013 and later:					
NO <sub>x</sub> aftertreatment system .....	(g)(6) (g)(7)			+0.3	
Diesel particulate filter (DPF) system .....	(g)(8)	2x			0.05/+0.04
Air-fuel ratio sensors upstream of aftertreatment devices .....	(g)(9)	2x	2x	+0.3	0.03/+0.02
Air-fuel ratio sensors downstream of aftertreatment devices .....	(g)(9)	2x		+0.3	0.05/+0.04
NO <sub>x</sub> sensors .....	(g)(9)			+0.3	0.05/+0.04
“Other monitors” with emissions thresholds .....	(g)(1) (g)(2) (g)(3) (g)(4) (g)(10)	2x	2x	+0.3	0.03/+0.02

Notes: FEL = Family Emissions Limit; 2.5x std means a multiple of 2.5 times the applicable emissions standard; +0.3 means the standard or FEL plus 0.3; 0.05/+0.04 means an absolute level of 0.05 or an additive level of the standard or FEL plus 0.04, whichever level is higher; these emissions thresholds apply to the monitoring requirements of paragraph (g) of this § 86.010–18.

(1) *Fuel system monitoring*—(i) *General.* The OBD system must monitor the fuel delivery system to verify that it is functioning properly. The individual electronic components (e.g., actuators, valves, sensors, pumps) that are used in the fuel system and are not specifically addressed in this paragraph (g)(1) must be monitored in accordance with the requirements of paragraph (i)(3) of this section.

(ii) *Fuel system malfunction criteria*—(A) *Fuel system pressure control.* The OBD system must monitor the fuel system's ability to control to the desired

fuel pressure. This monitoring must be done continuously unless new hardware has to be added, in which case the monitoring must be done at least once per drive cycle. The OBD system must detect a malfunction of the fuel system's pressure control system when the pressure control system is unable to maintain an engine's emissions at or below the emissions thresholds for “other monitors” as shown in Table 1 of this paragraph (g). For engines in which no failure or deterioration of the fuel system pressure control could result in an

engine's emissions exceeding the applicable emissions thresholds, the OBD system must detect a malfunction when the system has reached its control limits such that the commanded fuel system pressure cannot be delivered. For model year 2010 to 2012 engines with a unit injector fuel system, this requirement may be met by conducting a functional check of the fuel system pressure control in lieu of monitoring for conditions that could cause an engine's emissions to exceed the applicable emissions thresholds.

(B) *Fuel system injection quantity.* The OBD system must detect a malfunction of the fuel injection system when the system is unable to deliver the commanded quantity of fuel necessary to maintain an engine's emissions at or below the emissions thresholds for "other monitors" as shown in Table 1 of this paragraph (g). For engines in which no failure or deterioration of the fuel injection quantity could result in an engine's emissions exceeding the applicable emissions thresholds, the OBD system must detect a malfunction when the system has reached its control limits such that the commanded fuel quantity cannot be delivered. For model year 2010 to 2012 engines with a unit injector fuel system, this requirement may be met by conducting a functional check of the fuel system injection quantity in lieu of monitoring for conditions that could cause an engine's emissions to exceed the applicable emissions thresholds.

(C) *Fuel system injection timing.* The OBD system must detect a malfunction of the fuel injection system when the system is unable to deliver fuel at the proper crank angle/timing (e.g., injection timing too advanced or too retarded) necessary to maintain an engine's emissions at or below the emissions thresholds for "other monitors" as shown in Table 1 of this paragraph (g). For engines in which no failure or deterioration of the fuel injection timing could result in an engine's emissions exceeding the applicable emissions thresholds, the OBD system must detect a malfunction when the system has reached its control limits such that the commanded fuel injection timing cannot be achieved. For model year 2010 to 2012 engines with a unit injector

fuel system, this requirement may be met by conducting a functional check of the fuel system injection timing in lieu of monitoring for conditions that could cause an engine's emissions to exceed the applicable emissions thresholds.

(D) *Combined Monitoring.* For engines with a unit injector fuel system, the manufacturer may request Administrator approval to combine the malfunction criteria of paragraphs (g)(1)(ii)(A) through (g)(1)(ii)(C) of this section into one malfunction provided the manufacturer can demonstrate that the combined malfunction will satisfy the intent of each separate malfunction criteria. For engines with a common rail fuel system, the manufacturer may request Administrator approval to combine the malfunction criteria of paragraphs (g)(1)(ii)(B) through (g)(1)(ii)(C) of this section into one malfunction provided the manufacturer can demonstrate that the combined malfunction will satisfy the intent of each separate malfunction criteria.

(E) *Fuel system feedback control.* See paragraph (i)(6) of this section.

(iii) *Fuel system monitoring conditions.* (A) With the exceptions noted in this paragraph for unit injector systems, the OBD system must monitor continuously for malfunctions identified in paragraphs (g)(1)(ii)(A) and (g)(1)(ii)(E) of this section. For 2010 through 2012 unit injector systems, where functional monitoring is done in lieu of emission threshold monitoring for malfunctions identified in paragraph (g)(1)(ii)(A) of this section, the manufacturer must define the monitoring conditions in accordance with paragraphs (c) and (d) of this section. For 2013 and later unit injector systems, the manufacturer must define the monitoring conditions for malfunctions identified in paragraph (g)(1)(ii)(A) of this section in accordance with paragraphs (c) and (d) of this section, with the exception that monitoring must occur every time the monitoring conditions are met during the drive cycle rather than once per drive cycle as required in paragraph (c)(2) of this section.

(B) For 2010 through 2012, the manufacturer must define the monitoring conditions for malfunctions identified

in paragraphs (g)(1)(ii)(B), (g)(1)(ii)(C), and (g)(1)(ii)(D) of this section in accordance with paragraphs (c) and (d) of this section. For 2013 and later, the manufacturer must define the monitoring conditions in accordance with paragraphs (c) and (d) of this section, with the exception that monitoring must occur every time the monitoring conditions are met during the drive cycle rather than once per drive cycle as required in paragraph (c)(2) of this section.

(iv) *Fuel system MIL activation and DTC storage.* The MIL must activate and DTCs must be stored according to the provisions of paragraph (b) of this section.

(2) *Engine misfire monitoring—(i) General.* The OBD system must monitor the engine for misfire causing excess emissions.

(ii) *Engine misfire malfunction criteria.* (A) The OBD system must be capable of detecting misfire occurring in one or more cylinders. To the extent possible without adding hardware for this specific purpose, the OBD system must also identify the specific misfiring cylinder. If more than one cylinder is misfiring continuously, or if more than one but less than half of the cylinders are misfiring continuously (if the manufacturer can demonstrate the robustness of their monitor to the approval of the Administrator), a separate DTC must be stored indicating that multiple cylinders are misfiring. When identifying multiple cylinder misfire, the OBD system is not required to identify individually through separate DTCs each of the continuously misfiring cylinders.

(B) For model years 2013 and later, on engines equipped with sensors that can detect combustion or combustion quality (e.g., for use in engines with homogeneous charge compression ignition (HCCI) control systems), the OBD system must detect a misfire malfunction causing emissions to exceed the applicable thresholds for “other monitors” shown in Table 1 of this paragraph (g). To determine what level of misfire would cause emissions to exceed the applicable emissions thresholds, the manufacturer must determine the percentage of misfire evaluated in 1,000 revolution increments that would

cause emissions from an emission durability demonstration engine to exceed the emissions thresholds if the percentage of misfire were present from the beginning of the test. To establish this percentage of misfire, the manufacturer must use misfire events occurring at equally spaced, complete engine cycle intervals, across randomly selected cylinders throughout each 1,000-revolution increment. If this percentage of misfire is determined to be lower than one percent, the manufacturer may set the malfunction criteria at one percent. Any misfire malfunction must be detected if the percentage of misfire established via this testing is exceeded regardless of the pattern of misfire events (e.g., random, equally spaced, continuous). The manufacturer may employ other revolution increments besides the 1,000 revolution increment. To do so, the manufacturer must demonstrate that the strategy is equally effective and timely in detecting misfire.

(iii) *Engine misfire monitoring conditions.* (A) The OBD system must monitor for engine misfire during engine idle conditions at least once per drive cycle in which the monitoring conditions for misfire are met. The manufacturer must be able to demonstrate via engineering analysis and/or data that the self-defined monitoring conditions: are technically necessary to ensure robust detection of malfunctions (e.g., avoid false passes and false detection of malfunctions); require no more than 1000 cumulative engine revolutions; and, do not require any single continuous idle operation of more than 15 seconds to make a determination that a malfunction is present (e.g., a decision can be made with data gathered during several idle operations of 15 seconds or less); or, satisfy the requirements of paragraph (c) of this section with alternative engine operating conditions.

(B) Manufacturers may employ alternative monitoring conditions (e.g., off-idle) provided the manufacturer is able to demonstrate that the alternative monitoring ensure equivalent robust detection of malfunctions and equivalent timeliness in detection of malfunctions.

(C) For model years 2013 and later, on engines equipped with sensors that can

detect combustion or combustion quality the OBD system must monitor continuously for engine misfire under all positive torque engine speed and load conditions. If a monitoring system cannot detect all misfire patterns under all required engine speed and load conditions, the manufacturer may request that the Administrator approve the monitoring system nonetheless. In evaluating the manufacturer's request, the Administrator will consider the following factors: the magnitude of the region(s) in which misfire detection is limited; the degree to which misfire detection is limited in the region(s) (i.e., the probability of detection of misfire events); the frequency with which said region(s) are expected to be encountered in-use; the type of misfire patterns for which misfire detection is troublesome; and demonstration that the monitoring technology employed is not inherently incapable of detecting misfire under required conditions (i.e., compliance can be achieved on other engines). The evaluation will be based on the following misfire patterns: equally spaced misfire occurring on randomly selected cylinders; single cylinder continuous misfire; and, paired cylinder (cylinders firing at the same crank angle) continuous misfire.

(iv) *Engine misfire MIL activation and DTC storage.* (A) General requirements for MIL activation and DTC storage are set forth in paragraph (b) of this section.

(B) For model years 2013 and later, on engines equipped with sensors that can detect combustion or combustion quality, upon detection of the percentage of misfire specified in paragraph (g)(2)(ii)(B) of this section, the following criteria shall apply for MIL activation and DTC storage: A pending DTC must be stored no later than after the fourth exceedance of the percentage of misfire specified in paragraph (g)(2)(ii) of this section during a single drive cycle; if a pending fault code has been stored, the OBD system must activate the MIL and store a MIL-on DTC within 10 seconds if the percentage of misfire specified in paragraph (g)(2)(ii) of this section is again exceeded four times during the drive cycle immediately following storage of the pending DTC, regardless of the conditions

encountered during the drive cycle, or on the next drive cycle in which similar conditions are encountered to those that were occurring when the pending DTC was stored. Similar conditions means an engine speed within 375 rpm, engine load within 20 percent, and the same warm up status (i.e., cold or hot). The Administrator may approve other definitions of similar conditions based on comparable timeliness and reliability in detecting similar engine operation. The pending DTC may be erased at the end of the next drive cycle in which similar conditions are encountered to those that were occurring when the pending DTC was stored provided the specified percentage of misfire was not again exceeded. The pending DTC may also be erased if similar conditions are not encountered during the 80 drive cycles immediately following initial detection of the malfunction.

(C) For model years 2013 and later, on engines equipped with sensors that can detect combustion or combustion quality, the OBD system must store and erase freeze frame conditions either in conjunction with storing and erasing a pending DTC or in conjunction with storing and erasing a MIL-on DTC. If freeze frame conditions are stored for a malfunction other than a misfire malfunction when a DTC is stored as specified in paragraph (g)(2)(iv)(B) of this section, the stored freeze frame information must be replaced with the freeze frame information regarding the misfire malfunction.

(D) For model years 2013 and later, on engines equipped with sensors that can detect combustion or combustion quality, upon detection of misfire according to paragraph (g)(2)(iv)(B) of this section, the OBD system must also store the following engine conditions: engine speed, load, and warm up status of the first misfire event that resulted in the storage of the pending DTC.

(E) For model years 2013 and later, on engines equipped with sensors that can detect combustion or combustion quality, the MIL may be deactivated after three sequential drive cycles in which similar conditions have been encountered without an exceedance of the specified percentage of misfire.

(3) *EGR system monitoring*—(i) *General*. The OBD system must monitor the EGR system on engines so equipped for low flow rate, high flow rate, and slow response malfunctions. For engines equipped with EGR coolers (e.g., heat exchangers), the OBD system must monitor the cooler for insufficient cooling malfunctions. The individual electronic components (e.g., actuators, valves, sensors) that are used in the EGR system must be monitored in accordance with the comprehensive component requirements in paragraph (i)(3) of this section.

(ii) *EGR system malfunction criteria*—(A) *EGR low flow*. The OBD system must detect a malfunction of the EGR system prior to a decrease from the manufacturer's specified EGR flow rate that would cause an engine's emissions to exceed the emissions thresholds for "other monitors" as shown in Table 1 of this paragraph (g). For engines in which no failure or deterioration of the EGR system that causes a decrease in flow could result in an engine's emissions exceeding the applicable emissions thresholds, the OBD system must detect a malfunction when the system has reached its control limits such that it cannot increase EGR flow to achieve the commanded flow rate.

(B) *EGR high flow*. The OBD system must detect a malfunction of the EGR system, including a leaking EGR valve (i.e., exhaust gas flowing through the valve when the valve is commanded closed) prior to an increase from the manufacturer's specified EGR flow rate that would cause an engine's emissions to exceed the emissions thresholds for "other monitors" as shown in Table 1 of this paragraph (g). For engines in which no failure or deterioration of the EGR system that causes an increase in flow could result in an engine's emissions exceeding the applicable emissions thresholds, the OBD system must detect a malfunction when the system has reached its control limits such that it cannot reduce EGR flow to achieve the commanded flow rate.

(C) *EGR slow response*. The OBD system must detect a malfunction of the EGR system prior to any failure or deterioration in the capability of the EGR system to achieve the commanded flow rate within a manufacturer-speci-

fied time that would cause an engine's emissions to exceed the emissions thresholds for "other monitors" as shown in Table 1 of this paragraph (g). The OBD system must monitor both the capability of the EGR system to respond to a commanded increase in flow and the capability of the EGR system to respond to a commanded decrease in flow.

(D) *EGR system feedback control*. See paragraph (i)(6) of this section.

(E) *EGR cooler performance*. The OBD system must detect a malfunction of the EGR cooler prior to a reduction from the manufacturer's specified cooling performance that would cause an engine's emissions to exceed the emissions thresholds for "other monitors" as shown in Table 1 of this paragraph (g). For engines in which no failure or deterioration of the EGR cooler could result in an engine's emissions exceeding the applicable emissions thresholds, the OBD system must detect a malfunction when the system has no detectable amount of EGR cooling.

(iii) *EGR system monitoring conditions*. (A) The OBD system must monitor continuously for malfunctions identified in paragraphs (g)(3)(ii)(A), (g)(3)(ii)(B), and (g)(3)(ii)(D) of this section.

(B) The manufacturer must define the monitoring conditions for malfunctions identified in paragraph (g)(3)(ii)(C) of this section in accordance with paragraphs (c) and (d) of this section, with the exception that monitoring must occur every time the monitoring conditions are met during the drive cycle rather than once per drive cycle as required in paragraph (c)(2) of this section. For purposes of tracking and reporting as required in paragraph (d)(1) of this section, all monitors used to detect malfunctions identified in paragraph (g)(3)(ii)(C) of this section must be tracked separately but reported as a single set of values as specified in paragraph (e)(1)(iii) of this section.

(C) The manufacturer must define the monitoring conditions for malfunctions identified in paragraph (g)(3)(ii)(E) of this section in accordance with paragraphs (c) and (d) of this section. For purposes of tracking and reporting as required in paragraph (d)(1) of this section, all monitors used



to detect malfunctions identified in paragraph (g)(3)(ii)(E) of this section must be tracked separately but reported as a single set of values as specified in paragraph (e)(1)(iii) of this section.

(D) The manufacturer may request Administrator approval to disable temporarily the EGR system monitor(s) under specific ambient conditions (e.g., when freezing may affect performance of the system) or during specific operating conditions (e.g., transients, extreme low or high flow conditions). The manufacturer must be able to demonstrate via data or engineering analysis that a reliable system monitor cannot be run when these conditions exist because it cannot robustly distinguish between a malfunctioning system and a properly operating system. The manufacturer is still required to maintain comprehensive component monitoring as required in paragraph (i)(3) of this section.

(iv) *EGR system MIL activation and DTC storage.* The MIL must activate and DTCs must be stored according to the provisions of paragraph (b) of this section.

(4) *Turbo boost control system monitoring*—(i) *General.* The OBD system must monitor the boost pressure control system (e.g., turbocharger) on engines so equipped for under and over boost malfunctions. For engines equipped with variable geometry turbochargers (VGT), the OBD system must monitor the VGT system for slow response malfunctions. For engines equipped with charge air cooler systems, the OBD system must monitor the charge air cooler system for cooling system performance malfunctions. The individual electronic components (e.g., actuators, valves, sensors) that are used in the boost pressure control system must be monitored in accordance with the comprehensive component requirements in paragraph (i)(3) of this section.

(ii) *Turbo boost control system malfunction criteria*—(A) *Turbo underboost.* The OBD system must detect a malfunction of the boost pressure control system prior to a decrease from the manufacturer's commanded boost pressure, or expected boost pressure on engines not equipped with a boost pressure control

system, that would cause an engine's emissions to exceed the emissions thresholds for "other monitors" as shown in Table 1 of this paragraph (g). For engines in which no failure or deterioration of the boost pressure control system that causes a decrease in boost could result in an engine's emissions exceeding the applicable emissions thresholds, the OBD system must detect a malfunction when the system has reached its control limits such that it cannot increase boost to achieve the commanded boost pressure.

(B) *Turbo overboost.* The OBD system must detect a malfunction of the boost pressure control system on engines so equipped prior to an increase from the manufacturer's commanded boost pressure that would cause an engine's emissions to exceed the emissions thresholds for "other monitors" as shown in Table 1 of this paragraph (g). For engines in which no failure or deterioration of the boost pressure control system that causes an increase in boost could result in an engine's emissions exceeding the applicable emissions thresholds, the OBD system must detect a malfunction when the system has reached its control limits such that it cannot decrease boost to achieve the commanded boost pressure.

(C) *VGT slow response.* The OBD system must detect a malfunction prior to any failure or deterioration in the capability of the VGT system on engines so equipped to achieve the commanded turbocharger geometry within a manufacturer-specified time that would cause an engine's emissions to exceed the emissions thresholds for "other monitors" as shown in Table 1 of this paragraph (g). For engines in which no failure or deterioration of the VGT system response could result in an engine's emissions exceeding the applicable emissions thresholds, the OBD system must detect a malfunction of the VGT system when proper functional response of the system to computer commands does not occur.

(D) *Turbo boost feedback control.* See paragraph (i)(6) of this section.

(E) *Charge air undercooling.* The OBD system must detect a malfunction of the charge air cooling system prior to a decrease from the manufacturer's specified cooling rate that would cause

an engine's emissions to exceed the emissions thresholds for "other monitors" as shown in Table 1 of this paragraph (g). For engines in which no failure or deterioration of the charge air cooling system that causes a decrease in cooling performance could result in an engine's emissions exceeding the applicable emissions thresholds, the OBD system must detect a malfunction when the system has no detectable amount of charge air cooling.

(iii) *Turbo boost monitoring conditions.*

(A) The OBD system must monitor continuously for malfunctions identified in paragraphs (g)(4)(ii)(A), (g)(4)(ii)(B), and (g)(4)(ii)(D) of this section.

(B) The manufacturer must define the monitoring conditions for malfunctions identified in paragraph (g)(4)(ii)(C) of this section in accordance with paragraphs (c) and (d) of this section, with the exception that monitoring must occur every time the monitoring conditions are met during the drive cycle rather than once per drive cycle as required in paragraph (c)(2) of this section. For purposes of tracking and reporting as required in paragraph (d)(1) of this section, all monitors used to detect malfunctions identified in paragraph (g)(4)(ii)(C) of this section must be tracked separately but reported as a single set of values as specified in paragraph (e)(1)(iii) of this section.

(C) The manufacturer must define the monitoring conditions for malfunctions identified in paragraph (g)(4)(ii)(E) of this section in accordance with paragraphs (c) and (d) of this section. For purposes of tracking and reporting as required in paragraph (d)(1) of this section, all monitors used to detect malfunctions identified in paragraph (g)(4)(ii)(E) of this section must be tracked separately but reported as a single set of values as specified in paragraph (e)(1)(iii) of this section.

(D) The manufacturer may request Administrator approval to disable temporarily the turbo boost system monitor(s) during specific operating conditions (e.g., transients, extreme low or high flow conditions). The manufacturer must be able to demonstrate via data or engineering analysis that a reliable system monitor cannot be run

when these conditions exist because it cannot robustly distinguish between a malfunctioning system and a properly operating system. The manufacturer is still required to maintain comprehensive component monitoring as required in paragraph (i)(3) of this section.

(iv) *Turbo boost system MIL activation and DTC storage.* The MIL must activate and DTCs must be stored according to the provisions of paragraph (b) of this section.

(5) *NMHC converting catalyst monitoring*—(i) *General.* The OBD system must monitor the NMHC converting catalyst(s) for proper NMHC conversion capability. For purposes of this paragraph (g)(5), each catalyst that converts NMHC must be monitored either individually or in combination with others. For purposes of this paragraph (g)(5), NMHC conversion that may occur over the DPF or other aftertreatment devices is not included.

(ii) *NMHC converting catalyst malfunction criteria*—(A) *NMHC converting catalyst conversion efficiency.* The OBD system must detect a malfunction when the catalyst has no detectable amount of NMHC conversion capability.

(B) *NMHC converting catalyst aftertreatment assistance functions.* For catalysts used to generate an exotherm to assist DPF regeneration, the OBD system must detect a malfunction when the catalyst is unable to generate a sufficient exotherm to achieve DPF regeneration. In meeting this requirement, the OBD system must detect a malfunction when the DOC is unable to generate a temperature rise of 100 degrees C, or to reach the necessary DPF regeneration temperature, within 60 seconds of initiating an active DPF regeneration. Further, the OBD system must detect a malfunction when the DOC is unable to sustain the necessary regeneration temperature for the duration of the regeneration event. The OBD or control system must abort the regeneration if the regeneration temperature has not been reached within five minutes of initiating an active regeneration event, or if the regeneration temperature cannot be sustained for the duration of the regeneration event. As an alternative to these specific malfunction criteria, the manufacturer may employ different criteria. To do

so, the manufacturer must submit a description with supporting data, subject to Administrator approval, of their DPF regeneration monitoring strategy. The Administrator will consider the strategy's equivalence to the specific criteria stated in this paragraph when considering the request. Also as an alternative to these specific malfunction criteria, the manufacturer may employ an OBD monitor that detects a catalyst malfunction when the catalyst conversion capability decreases to the point that NMHC emissions exceed 2.5 times the applicable NMHC emission standard but must adjust emission test results pursuant to paragraph (f)(2) of this section. For catalysts located downstream of a DPF and used to convert NMHC emissions during DPF regeneration, the OBD system must detect a malfunction when the catalyst has no detectable amount of NMHC conversion capability unless the manufacturer can demonstrate that deterioration or malfunction of the catalyst will not result in emissions that exceed the applicable NMHC standard.

(iii) *NMHC converting catalyst monitoring conditions.* The manufacturer must define the monitoring conditions for malfunctions identified in paragraphs (g)(5)(ii)(A) and (g)(5)(ii)(B) of this section in accordance with paragraphs (c) and (d) of this section. For purposes of tracking and reporting as required in paragraph (d)(1) of this section, all monitors used to detect malfunctions identified in paragraphs (g)(5)(ii)(A) and (g)(5)(ii)(B) of this section must be tracked separately but reported as a single set of values as specified in paragraph (e)(1)(iii) of this section.

(iv) *NMHC converting catalyst MIL activation and DTC storage.* The MIL must activate and DTCs must be stored according to the provisions of paragraph (b) of this section. The monitoring method for the NMHC converting catalyst(s) must be capable of detecting all instances, except diagnostic self-clearing, when a catalyst DTC has been erased but the catalyst has not been replaced (e.g., catalyst over-temperature histogram approaches are not acceptable).

(6) *Selective catalytic reduction (SCR) and lean NO<sub>x</sub> catalyst monitoring—(i)*

*General.* The OBD system must monitor the SCR and/or the lean NO<sub>x</sub> converting catalyst(s) for proper conversion capability. For engines equipped with SCR systems or other catalyst systems that use an active/intrusive reductant injection (e.g., active lean NO<sub>x</sub> catalysts that use diesel fuel post-injection or in-exhaust injection), the OBD system must monitor the active/intrusive reductant injection system for proper performance. The individual electronic components (e.g., actuators, valves, sensors, heaters, pumps) in the active/intrusive reductant injection system must be monitored in accordance with the comprehensive component requirements in paragraph (i)(3) of this section. For purposes of this paragraph (g)(6), each catalyst that converts NO<sub>x</sub> must be monitored either individually or in combination with others.

(ii) *SCR and lean NO<sub>x</sub> catalyst malfunction criteria—(A) SCR and lean NO<sub>x</sub> catalyst conversion efficiency.* The OBD system must detect a catalyst malfunction when the catalyst conversion capability decreases to the point that would cause an engine's emissions to exceed the emissions thresholds for NO<sub>x</sub> aftertreatment systems as shown in Table 1 of this paragraph (g). If no failure or deterioration of the catalyst NO<sub>x</sub> conversion capability could result in an engine's emissions exceeding any of the applicable emissions thresholds, the OBD system must detect a malfunction when the catalyst has no detectable amount of NO<sub>x</sub> conversion capability.

(B) *SCR and lean NO<sub>x</sub> catalyst active/intrusive reductant delivery performance.* The OBD system must detect a malfunction prior to any failure or deterioration of the system to properly regulate reductant delivery (e.g., urea injection, separate injector fuel injection, post injection of fuel, air assisted injection/mixing) that would cause an engine's emissions to exceed any of the applicable emissions thresholds for NO<sub>x</sub> aftertreatment systems as shown in Table 1 of this paragraph (g). If no failure or deterioration of the reductant delivery system could result in an engine's emissions exceeding any of the applicable thresholds, the OBD system must detect a malfunction when the

system has reached its control limits such that it is no longer able to deliver the desired quantity of reductant.

(C) *SCR and lean NO<sub>x</sub> catalyst active/intrusive reductant quantity.* If the SCR or lean NO<sub>x</sub> catalyst system uses a reductant other than the fuel used for the engine, or uses a reservoir/tank for the reductant that is separate from the fuel tank used for the engine, the OBD system must detect a malfunction when there is no longer sufficient reductant available (e.g., the reductant tank is empty).

(D) *SCR and lean NO<sub>x</sub> catalyst active/intrusive reductant quality.* If the SCR or lean NO<sub>x</sub> catalyst system uses a reservoir/tank for the reductant that is separate from the fuel tank used for the engine, the OBD system must detect a malfunction when an improper reductant is used in the reductant reservoir/tank (e.g., the reductant tank is filled with something other than the reductant).

(E) *SCR and lean NO<sub>x</sub> catalyst active/intrusive reductant feedback control.* See paragraph (i)(6) of this section.

(iii) *SCR and lean NO<sub>x</sub> catalyst monitoring conditions.* (A) The manufacturers must define the monitoring conditions for malfunctions identified in paragraphs (g)(6)(ii)(A) and (g)(6)(ii)(D) of this section in accordance with paragraphs (c) and (d) of this section. For purposes of tracking and reporting as required in paragraph (d)(1) of this section, all monitors used to detect malfunctions identified in paragraph (g)(6)(ii)(A) of this section must be tracked separately but reported as a single set of values as specified in paragraph (e)(1)(iii) of this section.

(B) The OBD system must monitor continuously for malfunctions identified in paragraphs (g)(6)(ii)(B), (g)(6)(ii)(C), and (g)(6)(ii)(E) of this section.

(iv) *SCR and lean NO<sub>x</sub> catalyst MIL activation and DTC storage.* (A) For malfunctions identified in paragraph (g)(6)(ii)(A) of this section, the MIL must activate and DTCs must be stored according to the provisions of paragraph (b) of this section.

(B) For malfunctions identified in paragraphs (g)(6)(ii)(B), (g)(6)(ii)(C), and (g)(6)(ii)(D) of this section, the manufacturer may delay activating the

MIL if the vehicle is equipped with an alternative indicator for notifying the vehicle operator of the malfunction. The alternative indicator must be of sufficient illumination and be located such that it is readily visible to the vehicle operator under all lighting conditions. If the vehicle is not equipped with such an alternative indicator and the OBD MIL activates, the MIL may be immediately deactivated and the corresponding DTC(s) erased once the OBD system has verified that the reductant tank has been refilled properly and the MIL has not been activated for any other malfunction. The Administrator may approve other strategies that provide equivalent assurance that a vehicle operator would be promptly notified and that corrective action would be taken.

(C) The monitoring method for the SCR and lean NO<sub>x</sub> catalyst(s) must be capable of detecting all instances, except diagnostic self-clearing, when a catalyst DTC(s) has been erased but the catalyst has not been replaced (e.g., catalyst over-temperature histogram approaches are not acceptable).

(7) *NO<sub>x</sub> adsorber system monitoring*—(i) *General.* The OBD system must monitor the NO<sub>x</sub> adsorber on engines so-equipped for proper performance. For engines equipped with active/intrusive injection (e.g., in-exhaust fuel and/or air injection) to achieve desorption of the NO<sub>x</sub> adsorber, the OBD system must monitor the active/intrusive injection system for proper performance. The individual electronic components (e.g., injectors, valves, sensors) that are used in the active/intrusive injection system must be monitored in accordance with the comprehensive component requirements in paragraph (i)(3) of this section.

(ii) *NO<sub>x</sub> adsorber system malfunction criteria*—(A) *NO<sub>x</sub> adsorber system capability.* The OBD system must detect a NO<sub>x</sub> adsorber malfunction when its capability (i.e., its combined adsorption and conversion capability) decreases to the point that would cause an engine's NO<sub>x</sub> emissions to exceed the emissions thresholds for NO<sub>x</sub> aftertreatment systems as shown in Table 1 of this paragraph (g). If no failure or deterioration of the NO<sub>x</sub> adsorber capability could

result in an engine's NO<sub>x</sub> emissions exceeding the applicable emissions thresholds, the OBD system must detect a malfunction when the system has no detectable amount of NO<sub>x</sub> adsorber capability.

(B) *NO<sub>x</sub> adsorber system active/intrusive reductant delivery performance.* For NO<sub>x</sub> adsorber systems that use active/intrusive injection (e.g., in-cylinder post fuel injection, in-exhaust air-assisted fuel injection) to achieve desorption of the NO<sub>x</sub> adsorber, the OBD system must detect a malfunction if any failure or deterioration of the injection system's ability to properly regulate injection causes the system to be unable to achieve desorption of the NO<sub>x</sub> adsorber.

(C) *NO<sub>x</sub> adsorber system feedback control.* Malfunction criteria for the NO<sub>x</sub> adsorber and the NO<sub>x</sub> adsorber active/intrusive reductant delivery system are contained in paragraph (i)(6) of this section.

(iii) *NO<sub>x</sub> adsorber system monitoring conditions.* (A) The manufacturer must define the monitoring conditions for malfunctions identified in paragraph (g)(7)(ii)(A) of this section in accordance with paragraphs (c) and (d) of this section. For purposes of tracking and reporting as required in paragraph (d)(1) of this section, all monitors used to detect malfunctions identified in paragraph (g)(7)(ii)(A) of this section must be tracked separately but reported as a single set of values as specified in paragraph (e)(1)(iii) of this section.

(B) The OBD system must monitor continuously for malfunctions identified in paragraphs (g)(7)(ii)(B) and (g)(7)(ii)(C) of this section.

(iv) *NO<sub>x</sub> adsorber system MIL activation and DTC storage.* The MIL must activate and DTCs must be stored according to the provisions of paragraph (b) of this section.

(8) *Diesel particulate filter (DPF) system monitoring*—(i) *General.* The OBD system must monitor the DPF on engines so-equipped for proper performance. For engines equipped with active regeneration systems that use an active/intrusive injection (e.g., in-exhaust fuel injection, in-exhaust fuel/air burner), the OBD system must monitor the active/intrusive injection system

for proper performance. The individual electronic components (e.g., injectors, valves, sensors) that are used in the active/intrusive injection system must be monitored in accordance with the comprehensive component requirements in paragraph (i)(3) of this section.

(ii) *DPF system malfunction criteria*—(A) *DPF filtering performance.* The OBD system must detect a malfunction

prior to a decrease in the PM filtering capability of the DPF (e.g., cracking, melting, etc.) that would cause an engine's PM emissions to exceed the emissions thresholds for DPF systems as shown in Table 1 of this paragraph (g). If no failure or deterioration of the PM filtering performance could result in an engine's PM emissions exceeding the applicable emissions thresholds, the OBD system must detect a malfunction when no detectable amount of PM filtering occurs. As an alternative to a threshold monitor, the OBD system, on model year 2010 through 2012 engines only, can be designed to detect a malfunction based on a detectable decrease in the expected pressure drop across the DPF for a period of 5 seconds or more. The monitoring area for this alternative is determined using engine speed and load points defined in test cycles and procedures for the supplemental emissions test (SET) under § 86.1360-2007. The monitoring area shall include all engine speed and load points greater than a region bounded by a line connecting mode numbers 2, 6, 3, and 13 (i.e. A100, A75, B50, and C50). At engine speeds greater than "speed C", the monitor shall run whenever engine load is greater than 50%. For purposes of this paragraph, the detectable change in pressure drop is determined by operating the engine at the B50 engine speed and load point (as described in the SET test procedures), observing the pressure drop on a clean, nominal DPF, and multiplying the observed pressure drop by 0.5 or other factor supported by data and approved by the Administrator. The detectable change in pressure drop shall be reported in units of kilopascals (kPa). At time of certification, manufacturers shall provide the detectable change in pressure drop value along with OBD data stream parameters recorded with a clean DPF under the following nine engine speed/

load operating points of the SET: A50, A75, A100, B50, B75, B100, C50, C75, and C100. The OBD data stream parameters to be reported are described in (k)(4)(ii) of this section and shall include the following: Engine speed; calculated load; air flow rate from mass air flow sensor (if so equipped); fuel rate; and DPF delta pressure.

(B) *DPF regeneration frequency.* The OBD system must detect a malfunction when the DPF regeneration frequency increases from (i.e., occurs more often than) the manufacturer's specified regeneration frequency to a level such that it would cause an engine's NMHC emissions to exceed the emissions threshold for DPF systems as shown in Table 1 of this paragraph (g). If no such regeneration frequency exists that could cause NMHC emissions to exceed the applicable emission threshold, the OBD system must detect a malfunction when the DPF regeneration frequency exceeds the manufacturer's specified design limits for allowable regeneration frequency.

(C) *DPF incomplete regeneration.* The OBD system must detect a regeneration malfunction when the DPF does not properly regenerate under manufacturer-defined conditions where regeneration is designed to occur.

(D) *DPF missing substrate.* The OBD system must detect a malfunction if either the DPF substrate is completely destroyed, removed, or missing, or if the DPF assembly has been replaced with a muffler or straight pipe.

(E) *DPF system active/intrusive injection.* For DPF systems that use active/intrusive injection (e.g., in-cylinder post fuel injection, in-exhaust air-assisted fuel injection) to achieve regeneration of the DPF, the OBD system must detect a malfunction if any failure or deterioration of the injection system's ability to properly regulate injection causes the system to be unable to achieve regeneration of the DPF.

(F) *DPF regeneration feedback control.* See paragraph (i)(6) of this section.

(iii) *DPF monitoring conditions.* The manufacturer must define the monitoring conditions for malfunctions identified in paragraph (g)(8)(ii) of this section in accordance with paragraphs

(c) and (d) of this section, with the exception that monitoring must occur every time the monitoring conditions are met during the drive cycle rather than once per drive cycle as required in paragraph (c)(2) of this section. For OBD systems designed to the alternative malfunction criteria of paragraph (g)(8)(ii)(A) of this section, the alternative DPF monitor shall run continuously whenever engine speed and load conditions are within the monitoring area described in paragraph (g)(8)(ii)(A). The OBD system may make a malfunction or potential malfunction determination during any successful monitoring event but shall include in the enable criteria of any subsequent monitoring events a confirmed successful and complete DPF regeneration. The subsequent monitoring events must be conducted within an operating period that ensures that the detected malfunction has not "healed" due to trapped particulates in the compromised portion of the DPF substrate. For purposes of tracking and reporting as required in paragraph (d)(1) of this section, all monitors used to detect malfunctions identified in paragraph (g)(8)(ii) of this section must be tracked separately but reported as a single set of values as specified in paragraph (e)(1)(iii) of this section.

(iv) *DPF system MIL activation and DTC storage.* The MIL must activate and DTCs must be stored according to the provisions of paragraph (b) of this section.

(9) *Exhaust gas sensor and sensor heater monitoring*—(i) *General.* The OBD system must monitor for proper output signal, activity, response rate, and any other parameter that can affect emissions, all exhaust gas sensors (e.g., oxygen, air-fuel ratio, NO<sub>x</sub>) used for emission control system feedback (e.g., EGR control/feedback, SCR control/feedback, NO<sub>x</sub> adsorber control/feedback) and/or as a monitoring device. For engines equipped with heated exhaust gas sensors, the OBD system must monitor the heater for proper performance.

(ii) *Malfunction criteria for air-fuel ratio sensors located upstream of aftertreatment devices*—(A) *Sensor performance.* The OBD system must detect a malfunction prior to any failure or

deterioration of the sensor voltage, resistance, impedance, current, response rate, amplitude, offset, or other characteristic(s) that would cause an engine's emissions to exceed the emissions thresholds for "other monitors" as shown in Table 1 of this paragraph (g).

(B) *Circuit integrity*. The OBD system must detect malfunctions of the sensor related to a lack of circuit continuity or signal out-of-range values.

(C) *Feedback function*. The OBD system must detect a malfunction of the sensor if the emission control system (e.g., EGR, SCR, or NO<sub>x</sub> adsorber) is unable to use that sensor as a feedback input (e.g., causes limp-home or open-loop operation).

(D) *Monitoring function*. To the extent feasible, the OBD system must detect a malfunction of the sensor when the sensor output voltage, resistance, impedance, current, amplitude, activity, offset, or other characteristics are no longer sufficient for use as an OBD system monitoring device (e.g., for catalyst, EGR, SCR, or NO<sub>x</sub> adsorber monitoring).

(iii) *Malfunction criteria for air-fuel ratio sensors located downstream of aftertreatment devices*—(A) *Sensor performance*. The OBD system must detect a malfunction prior to any failure or deterioration of the sensor voltage, resistance, impedance, current, response rate, amplitude, offset, or other characteristic(s) that would cause an engine's emissions to exceed the emissions thresholds for air-fuel ratio sensors downstream of aftertreatment devices as shown in Table 1 of this paragraph (g).

(B) *Circuit integrity*. The OBD system must detect malfunctions of the sensor related to a lack of circuit continuity or signal out-of-range values.

(C) *Feedback function*. The OBD system must detect a malfunction of the sensor if the emission control system (e.g., EGR, SCR, or NO<sub>x</sub> adsorber) is unable to use that sensor as a feedback input (e.g., causes limp-home or open-loop operation).

(D) *Monitoring function*. To the extent feasible, the OBD system must detect a malfunction of the sensor when the sensor output voltage, resistance, impedance, current, amplitude, activity,

offset, or other characteristics are no longer sufficient for use as an OBD system monitoring device (e.g., for catalyst, EGR, SCR, or NO<sub>x</sub> adsorber monitoring).

(iv) *Malfunction criteria for NO<sub>x</sub> sensors*—(A) *Sensor performance*. The OBD system must detect a malfunction prior to any failure or deterioration of the sensor voltage, resistance, impedance, current, response rate, amplitude, offset, or other characteristic(s) that would cause an engine's emissions to exceed the emissions thresholds for NO<sub>x</sub> sensors as shown in Table 1 of this paragraph (g).

(B) *Circuit integrity*. The OBD system must detect malfunctions of the sensor related to a lack of circuit continuity or signal out-of-range values.

(C) *Feedback function*. The OBD system must detect a malfunction of the sensor if the emission control system (e.g., EGR, SCR, or NO<sub>x</sub> adsorber) is unable to use that sensor as a feedback input (e.g., causes limp-home or open-loop operation).

(D) *Monitoring function*. To the extent feasible, the OBD system must detect a malfunction of the sensor when the sensor output voltage, resistance, impedance, current, amplitude, activity, offset, or other characteristics are no longer sufficient for use as an OBD system monitoring device (e.g., for catalyst, EGR, SCR, or NO<sub>x</sub> adsorber monitoring).

(v) *Malfunction criteria for other exhaust gas sensors*. For other exhaust gas sensors, the manufacturer must submit a monitoring plan to the Administrator for approval. The plan must include data and/or engineering evaluations that demonstrate that the monitoring plan is as reliable and effective as the monitoring required in paragraphs (g)(9)(ii), (g)(9)(iii), (g)(9)(iv) of this section.

(vi) *Malfunction criteria for exhaust gas sensor heaters*. (A) The OBD system must detect a malfunction of the heater performance when the current or voltage drop in the heater circuit is no longer within the manufacturer's specified limits for normal operation (i.e., within the criteria required to be met by the component vendor for heater circuit performance at high mileage).

The manufacturer may use other malfunction criteria for heater performance malfunctions. To do so, the manufacturer must be able to demonstrate via data and/or an engineering evaluation that the monitor is reliable and robust.

(B) The OBD system must detect malfunctions of the heater circuit including open or short circuits that conflict with the commanded state of the heater (e.g., shorted to 12 Volts when commanded to 0 Volts (ground)).

(vii) *Monitoring conditions for exhaust gas sensors.* (A) The manufacturer must define the monitoring conditions for malfunctions identified in paragraphs (g)(9)(ii)(A), (g)(9)(iii)(A), and (g)(9)(iv)(A) of this section (i.e., sensor performance) in accordance with paragraphs (c) and (d) of this section. For purposes of tracking and reporting as required in paragraph (d)(1) of this section, all monitors used to detect malfunctions identified in paragraphs (g)(9)(ii)(A), (g)(9)(iii)(A), and (g)(9)(iv)(A) of this section must be tracked separately but reported as a single set of values as specified in paragraph (e)(1)(iii) of this section.

(B) The manufacturer must define the monitoring conditions for malfunctions identified in paragraphs (g)(9)(ii)(D), (g)(9)(iii)(D), and (g)(9)(iv)(D) of this section (i.e., monitoring function) in accordance with paragraphs (c) and (d) of this section with the exception that monitoring must occur every time the monitoring conditions are met during the drive cycle rather than once per drive cycle as required in paragraph (c)(2) of this section.

(C) Except as provided for in paragraph (g)(9)(vii)(D) of this section, the OBD system must monitor continuously for malfunctions identified in paragraphs (g)(9)(ii)(B), (g)(9)(ii)(C), (g)(9)(iii)(B), (g)(9)(iii)(C), (g)(9)(iv)(B), (g)(9)(iv)(C) of this section (i.e., circuit integrity and feedback function).

(D) A manufacturer may request approval to disable continuous exhaust gas sensor monitoring when an exhaust gas sensor malfunction cannot be distinguished from other effects (e.g., disable monitoring for out-of-range on the low side during fuel cut conditions). To do so, the manufacturer must dem-

onstrate via data and/or engineering analyses that a properly functioning sensor cannot be distinguished from a malfunctioning sensor and that the disablement interval is limited only to that necessary for avoiding false malfunction detection.

(viii) *Monitoring conditions for exhaust gas sensor heaters*—(A) The manufacturer must define monitoring conditions for malfunctions identified in paragraph (g)(9)(vi)(A) of this section (i.e., sensor heater performance) in accordance with paragraphs (c) and (d) of this section.

(B) The OBD system must monitor continuously for malfunctions identified in paragraph (g)(9)(vi)(B) of this section (i.e., circuit malfunctions).

(ix) *Exhaust gas sensor and sensor heater MIL activation and DTC storage.* The MIL must activate and DTCs must be stored according to the provisions of paragraph (b) of this section.

(10) *Variable Valve Timing (VVT) system monitoring*—(i) *General.* The OBD system must monitor the VVT system on engines so equipped for target error and slow response malfunctions. The individual electronic components (e.g., actuators, valves, sensors) that are used in the VVT system must be monitored in accordance with the comprehensive components requirements in paragraph (i)(3) of this section.

(ii) *VVT system malfunction criteria*—(A) *VVT system target error.* The OBD system must detect a malfunction prior to any failure or deterioration in the capability of the VVT system to achieve the commanded valve timing and/or control within a crank angle and/or lift tolerance that would cause an engine's emissions to exceed the emission thresholds for "other monitors" as shown in Table 1 of this paragraph (g).

(B) *VVT slow response.* The OBD system must detect a malfunction prior to any failure or deterioration in the capability of the VVT system to achieve the commanded valve timing and/or control within a manufacturer-specified time that would cause an engine's emissions to exceed the emission thresholds for "other monitors" as shown in Table 1 of this paragraph (g).

(C) For engines in which no failure or deterioration of the VVT system could



result in an engine's emissions exceeding the applicable emissions thresholds of paragraphs (g)(10)(ii)(A) and (g)(10)(ii)(B) of this section, the OBD system must detect a malfunction of the VVT system when proper functional response of the system to computer commands does not occur.

(iii) *VVT system monitoring conditions.* Manufacturers must define the monitoring conditions for VVT system malfunctions identified in paragraph (g)(10)(ii) of this section in accordance with paragraphs (c) and (d) of this section, with the exception that monitoring must occur every time the monitoring conditions are met during the drive cycle rather than once per drive cycle as required in paragraph (c)(2) of this section. For purposes of tracking

and reporting as required in paragraph (d)(1) of this section, all monitors used to detect malfunctions identified in paragraph (g)(10)(ii) of this section must be tracked separately but reported as a single set of values as specified in paragraph (e)(1)(iii) of this section.

(iv) *VVT MIL activation and DTC storage.* The MIL must activate and DTCs must be stored according to the provisions of paragraph (b) of this section.

(h) *OBD monitoring requirements for gasoline-fueled/spark-ignition engines.* The following table shows the thresholds at which point certain components or systems, as specified in this paragraph (h), are considered malfunctioning.

TABLE 2—OBD EMISSIONS THRESHOLDS FOR GASOLINE-FUELED/SPARK-IGNITION ENGINES MEANT FOR PLACEMENT IN APPLICATIONS GREATER THAN 14,000 POUNDS GVWR (G/BHP-HR)

Component	NO <sub>x</sub>	NMHC	CO	§ 86.010-18 reference
Catalyst system .....	1.75x std .....	1.75x std .....	.....	(h)(6)
Evaporative emissions control system.	.....	0.150 inch leak .....	.....	(h)(7)
"Other monitors" with emissions thresholds.	1.5x std .....	1.5x std .....	1.5x std .....	(h)(1), (h)(2), (h)(3), (h)(4), (h)(5), (h)(8), (h)(9)

Notes: 1.75x std means a multiple of 1.75 times the applicable emissions standard; these emissions thresholds apply to the monitoring requirements of paragraph (h) of this section; The evaporative emissions control system threshold is not, technically, an emissions threshold but rather a leak size that must be detected; nonetheless, for ease we refer to this as the threshold.

(1) *Fuel system monitoring—(i) General.* The OBD system must monitor the fuel delivery system to determine its ability to provide compliance with emission standards.

(ii) *Fuel system malfunction criteria.* (A) The OBD system must detect a malfunction of the fuel delivery system (including feedback control based on a secondary oxygen sensor) when the fuel delivery system is unable to maintain an engine's emissions at or below the emissions thresholds for "other monitors" as shown in Table 2 of this paragraph (h).

(B) Except as provided for in paragraph (h)(1)(ii)(C) of this section, if the engine is equipped with adaptive feedback control, the OBD system must detect a malfunction when the adaptive feedback control has used up all of the adjustment allowed by the manufacturer.

(C) If the engine is equipped with feedback control that is based on a secondary oxygen (or equivalent) sensor, the OBD system is not required to detect a malfunction of the fuel system solely when the feedback control based on a secondary oxygen sensor has used up all of the adjustment allowed by the manufacturer. However, if a failure or deterioration results in engine emissions that exceed the emissions thresholds for "other monitors" as shown in Table 2 of this paragraph (h), the OBD system is required to detect a malfunction.

(D) The OBD system must detect a malfunction whenever the fuel control system fails to enter closed loop operation following engine start within a manufacturer specified time interval. The specified time interval must be supported by data and/or engineering analyses submitted by the manufacturer.

(E) The manufacturer may adjust the malfunction criteria and/or monitoring conditions to compensate for changes in altitude, for temporary introduction of large amounts of purge vapor, or for other similar identifiable operating conditions when such conditions occur.

(iii) *Fuel system monitoring conditions.* The fuel system must be monitored continuously for the presence of a malfunction.

(iv) *Fuel system MIL activation and DTC storage.* (A) A pending DTC must be stored immediately upon the fuel system exceeding the malfunction criteria established in paragraph (h)(1)(ii) of this section.

(B) Except as provided for in paragraph (h)(1)(iv)(C) of this section, if a pending DTC is stored, the OBD system must activate the MIL immediately and store a MIL-on DTC if a malfunction is again detected during either the drive cycle immediately following storage of the pending DTC regardless of the conditions encountered during that drive cycle, or on the next drive cycle in which similar conditions are encountered to those that occurred when the pending DTC was stored. Similar conditions means engine conditions having an engine speed within 375 rpm, load conditions within 20 percent, and the same warm-up status (i.e., cold or hot) as the engine conditions stored pursuant to paragraph (h)(1)(iv)(E) of this section. Other definitions of similar conditions may be used but must result in comparable timeliness and reliability in detecting similar engine operation.

(C) The pending DTC may be erased at the end of the next drive cycle in which similar conditions have been encountered without having again exceeded the specified fuel system malfunction criteria. The pending DTC may also be erased if similar conditions are not encountered during the 80 drive cycles immediately following detection of the potential malfunction for which the pending DTC was stored.

(D) *Storage of freeze frame conditions.* The OBD system must store and erase freeze frame conditions either in conjunction with storing and erasing a pending DTC or in conjunction with storing and erasing a MIL-on DTC. Freeze frame information associated

with a fuel system malfunction shall be stored in preference to freeze frame information required elsewhere in paragraphs (h) or (i) of this section.

(E) Storage of fuel system conditions for determining similar conditions of operation. The OBD must store the engine speed, load, and warm-up status present at the time it first detects a potential malfunction meeting the criteria of paragraph (h)(1)(ii) of this section and stores a pending DTC.

(F) Deactivating the MIL. The MIL may be extinguished after three sequential driving cycles in which similar conditions have been encountered without detecting a malfunction of the fuel system.

(2) *Engine misfire monitoring*—(i) *General.* (A) The OBD system must monitor the engine for misfire causing catalyst damage and misfire causing excess emissions.

(B) The OBD system must identify the specific cylinder that is misfiring. The manufacturer may store a general misfire DTC instead of a cylinder specific DTC under certain operating conditions. To do so, the manufacturer must submit data and/or engineering analyses that demonstrate that the misfiring cylinder cannot be identified reliably when the conditions occur.

(C) If more than one cylinder is misfiring, a separate DTC must be stored to indicate that multiple cylinders are misfiring unless otherwise allowed by this paragraph (h)(2). When identifying multiple cylinder misfire, the OBD system is not required to also identify using separate DTCs each of the misfiring cylinders individually. If more than 90 percent of the detected misfires occur in a single cylinder, an appropriate DTC may be stored that indicates the specific misfiring cylinder rather than storing the multiple cylinder misfire DTC. If two or more cylinders individually have more than 10 percent of the total number of detected misfires, a multiple cylinder DTC must be stored.

(ii) *Engine misfire malfunction criteria*—(A) *Misfire causing catalyst damage.* The manufacturer must determine the percentage of misfire evaluated in 200 revolution increments for each engine speed and load condition that would result in a temperature that

causes catalyst damage. If this percentage of misfire is exceeded, it shall be considered a malfunction that must be detected. For every engine speed and load condition for which this percentage of misfire is determined to be lower than five percent, the manufacturer may set the malfunction criteria at five percent. The manufacturer may use a longer interval than 200 revolutions but only for determining, on a given drive cycle, the first misfire exceedance as provided in paragraph (h)(2)(iv)(A) of this section. To do so, the manufacturer must demonstrate that the interval is not so long that catalyst damage would occur prior to the interval being elapsed.

(B) *Misfire causing emissions to exceed the applicable thresholds.* The manufacturer must determine the percentage of misfire evaluated in 1000 revolution increments that would cause emissions from an emissions durability demonstration engine to exceed the emissions thresholds for "other monitors" as shown in Table 2 of this paragraph (h) if that percentage of misfire were present from the beginning of the test. If this percentage of misfire is exceeded, regardless of the pattern of misfire events (e.g., random, equally spaced, continuous), it shall be considered a malfunction that must be detected. To establish this percentage of misfire, the manufacturer must use misfire events occurring at equally spaced, complete engine cycle intervals, across randomly selected cylinders throughout each 1000-revolution increment. If this percentage of misfire is determined to be lower than one percent, the manufacturer may set the malfunction criteria at one percent. The manufacturer may use a longer interval than 1000 revolutions. To do so, the manufacturer must demonstrate that the strategy would be equally effective and timely at detecting misfire.

(iii) *Engine misfire monitoring conditions.* (A) The OBD system must monitor continuously for misfire under the following conditions: from no later than the end of the second crankshaft revolution after engine start; during the rise time and settling time for engine speed to reach the desired idle engine speed at engine start-up (i.e., "flare-up" and "flare-down"); and,

under all positive torque engine speeds and load conditions except within the engine operating region bound by the positive torque line (i.e., engine load with the transmission in neutral), and the points represented by an engine speed of 3000 rpm with the engine load at the positive torque line and the redline engine speed with the engine's manifold vacuum at four inches of mercury lower than that at the positive torque line. For this purpose, redline engine speed is defined as either the recommended maximum engine speed as displayed on the instrument panel tachometer, or the engine speed at which fuel shutoff occurs.

(B) If an OBD monitor cannot detect all misfire patterns under all required engine speed and load conditions as required by paragraph (h)(2)(iii)(A) of this section, the OBD system may still be acceptable. The Administrator will evaluate the following factors in making a determination: The magnitude of the region(s) in which misfire detection is limited; the degree to which misfire detection is limited in the region(s) (i.e., the probability of detection of misfire events); the frequency with which said region(s) are expected to be encountered in-use; the type of misfire patterns for which misfire detection is troublesome; and demonstration that the monitoring technology employed is not inherently incapable of detecting misfire under the required conditions (i.e., compliance can be achieved on other engines). The evaluation will be based on the following misfire patterns: equally spaced misfire occurring on randomly selected cylinders; single cylinder continuous misfire; and paired cylinder (cylinders firing at the same crank angle) continuous misfire.

(C) The manufacturer may use monitoring system that has reduced misfire detection capability during the portion of the first 1000 revolutions after engine start that a cold start emission reduction strategy is active that reduces engine torque (e.g., spark retard strategies). To do so, the manufacturer must demonstrate that the probability of detection is greater than or equal to 75 percent during the worst case condition (i.e., lowest generated torque) for a vehicle operated continuously at idle

(park/neutral idle) on a cold start between 50 and 86 degrees Fahrenheit and that the technology cannot reliably detect a higher percentage of the misfire events during the conditions.

(D) The manufacturer may disable misfire monitoring or use an alternative malfunction criterion when misfire cannot be distinguished from other effects. To do so, the manufacturer must demonstrate that the disablement interval or the period of use of an alternative malfunction criterion is limited only to that necessary for avoiding false detection and for one or more of the following operating conditions: Rough road; fuel cut; gear changes for manual transmission vehicles; traction control or other vehicle stability control activation such as anti-lock braking or other engine torque modifications to enhance vehicle stability; off-board control or intrusive activation of vehicle components or monitors during service or assembly plant testing; portions of intrusive evaporative system or EGR monitors that can significantly affect engine stability (i.e., while the purge valve is open during the vacuum pull-down of an evaporative system leak check but not while the purge valve is closed and the evaporative system is sealed or while an EGR monitor causes the EGR valve to be cycled intrusively on and off during positive torque conditions); or, engine speed, load, or torque transients due to throttle movements more rapid than those that occur over the FTP cycle for the worst case engine within each engine family. In general, the Administrator will not approve disablement for conditions involving normal air conditioning compressor cycling from on-to-off or off-to-on, automatic transmission gear shifts (except for shifts occurring during wide open throttle operation), transitions from idle to off-idle, normal engine speed or load changes that occur during the engine speed rise time and settling time (i.e., “flare-up” and “flare-down”) immediately after engine starting without any vehicle operator-induced actions (e.g., throttle stabs), or excess acceleration (except for acceleration rates that exceed the maximum acceleration rate obtainable at wide open throttle while the vehicle is in gear due

to abnormal conditions such as slipping of a clutch). The Administrator may approve misfire monitoring disablement or use of an alternate malfunction criterion for any other condition on a case by case basis upon determining that the manufacturer has demonstrated that the request is based on an unusual or unforeseen circumstance and that it is applying the best available computer and monitoring technology.

(E) For engines with more than eight cylinders that cannot meet the requirements of paragraph (h)(2)(iii)(A) of this section, a manufacturer may use alternative misfire monitoring conditions. Such use must be based on data and/or an engineering evaluation submitted by the manufacturer that demonstrate that misfire detection throughout the required operating region cannot be achieved when employing proven monitoring technology (i.e., a technology that provides for compliance with these requirements on other engines) and provided misfire is detected to the fullest extent permitted by the technology. However, the misfire detection system must still monitor during all positive torque operating conditions encountered during an FTP cycle.

(iv) *MIL activation and DTC storage for engine misfire causing catalyst damage—(A) Pending DTCs.* A pending DTC must be stored immediately if, during a single drive cycle, the specified misfire percentage described in paragraph (h)(2)(ii)(A) of this section is exceeded three times when operating in the positive torque region encountered during a FTP cycle or is exceeded on a single occasion when operating at any other engine speed and load condition in the positive torque region defined in paragraph (h)(2)(iii)(A) of this section. Immediately after a pending DTC is stored pursuant to this paragraph, the MIL must blink once per second at all times during the drive cycle that engine misfire is occurring. The MIL may be deactivated during those times that misfire is not occurring. If, at the time that a catalyst damaging misfire malfunction occurs, the MIL is already activated for a malfunction other than misfire, the MIL must still blink once per second at all times during the drive cycle that engine misfire is occurring.

If misfire ceases, the MIL must stop blinking but remain activated as appropriate in accordance with the other malfunction.

(B) *MIL-on DTCs.* If a pending DTC is stored in accordance with paragraph (h)(2)(iv)(A) of this section, the OBD system must immediately store a MIL-on DTC if the percentage of misfire described in paragraph (h)(2)(ii)(A) of this section is again exceeded one or more times during either the drive cycle immediately following storage of the pending DTC, regardless of the conditions encountered during that drive cycle, or on the next drive cycle in which similar conditions are encountered to those that occurred when the pending DTC was stored. If, during a previous drive cycle, a pending DTC is stored in accordance with paragraph (h)(2)(iv)(A) of this section, a MIL-on DTC must be stored immediately upon exceeding the percentage misfire described in paragraph (h)(2)(ii)(A) of this section regardless of the conditions encountered. Upon storage of a MIL-on DTC, the MIL must blink once per second at all times during the drive cycle that engine misfire is occurring. If misfire ceases, the MIL must stop blinking but remain activated until the conditions are met for extinguishing the MIL.

(C) *Erase of pending DTCs.* Pending DTCs stored in accordance with paragraph (h)(2)(iv)(A) of this section must be erased at the end of the next drive cycle in which similar conditions are encountered to those that occurred when the pending DTC was stored provided no exceedances have been detected of the misfire percentage described in paragraph (h)(2)(ii)(A) of this section. The pending DTC may also be erased if similar conditions are not encountered during the next 80 drive cycles immediately following storage of the pending DTC.

(D) *Exemptions for engines with fuel shutoff and default fuel control.* In engines that provide for fuel shutoff and default fuel control to prevent over fueling during catalyst damaging misfire conditions, the MIL need not blink as required by paragraphs (h)(2)(iv)(A) and (h)(2)(iv)(B) of this section. Instead, the MIL may be activated continuously upon misfire detection pro-

vided that the fuel shutoff and default fuel control are activated immediately upon misfire detection. Fuel shutoff and default fuel control may be deactivated only when the engine is outside of the misfire range except that the manufacturer may periodically, but not more than once every 30 seconds, deactivate fuel shutoff and default fuel control to determine if the catalyst damaging misfire is still occurring. Normal fueling and fuel control may be resumed if the catalyst damaging misfire is no longer occurring.

(E) The manufacturer may use a strategy that activates the MIL continuously rather than blinking the MIL during extreme catalyst damage misfire conditions (i.e., catalyst damage misfire occurring at all engine speeds and loads). Use of such a strategy must be limited to catalyst damage misfire levels that cannot be avoided during reasonable driving conditions. To use such a strategy, the manufacturer must be able to demonstrate that the strategy will encourage operation of the vehicle in conditions that will minimize catalyst damage (e.g., at low engine speeds and loads).

(v) *MIL activation and DTC storage for engine misfire causing emissions to exceed applicable emissions thresholds.* (A) Immediately upon detection, during the first 1000 revolutions after engine start of the misfire percentage described in paragraph (h)(2)(ii)(B) of this section, a pending DTC must be stored. If such a pending DTC is stored already and another such exceedance of the misfire percentage is detected within the first 1000 revolutions after engine start on any subsequent drive cycle, the MIL must activate and a MIL-on DTC must be stored. The pending DTC may be erased if, at the end of the next drive cycle in which similar conditions are encountered to those that occurred when the pending DTC was stored, there has been no exceedance of the misfire percentage described in paragraph (h)(2)(ii)(B) of this section. The pending DTC may also be erased if similar conditions are not encountered during the next 80 drive cycles immediately following storage of the pending DTC.

(B) No later than the fourth detection during a single drive cycle, following the first 1000 revolutions after engine start of the misfire percentage described in paragraph (h)(2)(ii)(B) of this section, a pending DTC must be stored. If such a pending DTC is stored already, then the MIL must activate and a MIL-on DTC must be stored within 10 seconds of the fourth detection of the misfire percentage described in paragraph (h)(2)(ii)(B) of this section during either the drive cycle immediately following storage of the pending DTC, regardless of the conditions encountered during that drive cycle excepting those conditions within the first 1000 revolutions after engine start, or on the next drive cycle in which similar conditions are encountered to those that occurred when the pending DTC was stored excepting those conditions within the first 1000 revolutions after engine start. The pending DTC may be erased if, at the end of the next drive cycle in which similar conditions are encountered to those that occurred when the pending DTC was stored, there has been no exceedance of the misfire percentage described in paragraph (h)(2)(ii)(B) of this section. The pending DTC may also be erased if similar conditions are not encountered during the next 80 drive cycles immediately following storage of the pending DTC.

(vi) *Storage of freeze frame conditions for engine misfire.* (A) The OBD system must store and erase freeze frame conditions (as defined in paragraph (k)(4)(iii) of this section) either in conjunction with storing and erasing a pending DTC or in conjunction with storing and erasing a MIL-on DTC.

(B) If, upon storage of a DTC as required by paragraphs (h)(2)(iv) and (h)(2)(v) of this section, there already exist stored freeze frame conditions for a malfunction other than a misfire or fuel system malfunction (see paragraph (h)(1) of this section) then the stored freeze frame information shall be replaced with freeze frame information associated with the misfire malfunction.

(vii) *Storage of engine conditions in association with engine misfire.* Upon detection of the misfire percentages described in paragraphs (h)(2)(ii)(A) and

(h)(2)(ii)(B) of this section, the following engine conditions must be stored for use in determining similar conditions: Engine speed, load, and warm up status of the first misfire event that resulted in pending DTC storage.

(viii) *MIL deactivation in association with engine misfire.* The MIL may be deactivated after three sequential drive cycles in which similar conditions have been encountered without an exceedance of the misfire percentages described in paragraphs (h)(2)(ii)(A) and (h)(2)(ii)(B) of this section.

(3) *Exhaust gas recirculation system monitoring—(i) General.* The OBD system must monitor the EGR system on engines so equipped for low and high flow rate malfunctions. The individual electronic components (e.g., actuators, valves, sensors) that are used in the EGR system must be monitored in accordance with the comprehensive component requirements in paragraph (i)(3) of this section.

(ii) *EGR system malfunction criteria.* (A) The OBD system must detect a malfunction of the EGR system prior to a decrease from the manufacturer's specified EGR flow rate that would cause an engine's emissions to exceed the emissions thresholds for "other monitors" as shown in Table 2 of this paragraph (h). For engines in which no failure or deterioration of the EGR system that causes a decrease in flow could result in an engine's emissions exceeding the applicable emissions thresholds, the OBD system must detect a malfunction when the system has no detectable amount of EGR flow.

(B) The OBD system must detect a malfunction of the EGR system prior to an increase from the manufacturer's specified EGR flow rate that would cause an engine's emissions to exceed the emissions thresholds for "other monitors" as shown in Table 2 of this paragraph (h). For engines in which no failure or deterioration of the EGR system that causes an increase in flow could result in an engine's emissions exceeding the applicable emissions thresholds, the OBD system must detect a malfunction when the system has reached its control limits such that it cannot reduce EGR flow.

(iii) *EGR system monitoring conditions.* (A) The manufacturer must define the monitoring conditions for malfunctions identified in paragraph (h)(3)(ii) of this section in accordance with paragraphs (c) and (d) of this section. For purposes of tracking and reporting as required by paragraph (d)(1) of this section, all monitors used to detect malfunctions identified in paragraph (h)(3)(ii) of this section must be tracked separately but reported as a single set of values as specified in paragraph (e)(1)(iii) of this section.

(B) The manufacturer may disable temporarily the EGR monitor under conditions when monitoring may not be reliable (e.g., when freezing may affect performance of the system). To do so, the manufacturer must be able to demonstrate that the monitor is unreliable when such conditions exist.

(iv) *EGR system MIL activation and DTC storage.* The MIL must activate and DTCs must be stored according to the provisions of paragraph (b) of this section.

(4) *Cold start emission reduction strategy monitoring*—(i) *General.* If an engine incorporates a specific engine control strategy to reduce cold start emissions, the OBD system must monitor the key components (e.g., idle air control valve), other than secondary air, while the control strategy is active to ensure proper operation of the control strategy.

(ii) *Cold start strategy malfunction criteria.* (A) The OBD system must detect a malfunction prior to any failure or deterioration of the individual components associated with the cold start emission reduction control strategy that would cause an engine's emissions to exceed the emissions thresholds for "other monitors" as shown in Table 2 of this paragraph (h). The manufacturer must establish the malfunction criteria based on data from one or more representative engine(s) and provide an engineering evaluation for establishing the malfunction criteria for the remainder of the manufacturer's product line.

(B) Where no failure or deterioration of a component used for the cold start emission reduction strategy could result in an engine's emissions exceeding the applicable emissions thresholds,

the individual component must be monitored for proper functional response while the control strategy is active in accordance with the malfunction criteria in paragraphs (i)(3)(ii) and (i)(3)(iii) of this section.

(iii) *Cold start strategy monitoring conditions.* The manufacturer must define monitoring conditions for malfunctions identified in paragraph (h)(4)(ii) of this section in accordance with paragraphs (c) and (d) of this section.

(iv) *Cold start strategy MIL activation and DTC storage.* The MIL must activate and DTCs must be stored according to the provisions of paragraph (b) of this section.

(5) *Secondary air system monitoring*—(i) *General.* The OBD system on engines equipped with any form of secondary air delivery system must monitor the proper functioning of the secondary air delivery system including all air switching valve(s). The individual electronic components (e.g., actuators, valves, sensors) that are used in the secondary air system must be monitored in accordance with the comprehensive component requirements in paragraph (i)(3) of this section. For purposes of this paragraph (h)(5), "air flow" is defined as the air flow delivered by the secondary air system to the exhaust system. For engines using secondary air systems with multiple air flow paths/distribution points, the air flow to each bank (i.e., a group of cylinders that share a common exhaust manifold, catalyst, and control sensor) must be monitored in accordance with the malfunction criteria in paragraph (h)(5)(ii) of this section. Also for purposes of this paragraph (h)(5), "normal operation" is defined as the condition when the secondary air system is activated during catalyst and/or engine warm-up following engine start. "Normal operation" does not include the condition when the secondary air system is turned on intrusively for the sole purpose of monitoring.

(ii) *Secondary air system malfunction criteria.* (A) Except as provided in paragraph (h)(5)(ii)(C) of this section, the OBD system must detect a secondary air system malfunction prior to a decrease from the manufacturer's specified air flow during normal operation that would cause an engine's emissions

to exceed the emissions thresholds for “other monitors” as shown in Table 2 of this paragraph (h).

(B) Except as provided in paragraph (h)(5)(ii)(C) of this section, the OBD system must detect a secondary air system malfunction prior to an increase from the manufacturer’s specified air flow during normal operation that would cause an engine’s emissions to exceed the emissions thresholds for “other monitors” as shown in Table 2 of this paragraph (h).

(C) For engines in which no deterioration or failure of the secondary air system would result in an engine’s emissions exceeding the applicable emissions thresholds, the OBD system must detect a malfunction when no detectable amount of air flow is delivered by the secondary air system during normal operation.

(iii) *Secondary air system monitoring conditions.* The manufacturer must define monitoring conditions for malfunctions identified in paragraph (h)(5)(ii) of this section in accordance with paragraphs (c) and (d) of this section. For purposes of tracking and reporting as required by paragraph (d)(1) of this section, all monitors used to detect malfunctions identified in paragraph (h)(5)(ii) of this section must be tracked separately but reported as a single set of values as specified in paragraph (e)(1)(iii) of this section.

(iv) *Secondary air system MIL activation and DTC storage.* The MIL must activate and DTCs must be stored according to the provisions of paragraph (b) of this section.

(6) *Catalyst system monitoring—(i) General.* The OBD system must monitor the catalyst system for proper conversion capability.

(ii) *Catalyst system malfunction criteria.* The OBD system must detect a catalyst system malfunction when the catalyst system’s conversion capability decreases to the point that emissions exceed the emissions thresholds for the catalyst system as shown in Table 2 of this paragraph (h).

(iii) *Catalyst system monitoring conditions.* The manufacturer must define monitoring conditions for malfunctions identified in paragraph (h)(6)(ii) of this section in accordance with paragraphs (c) and (d) of this section. For

purposes of tracking and reporting as required by paragraph (d)(1) of this section, all monitors used to detect malfunctions identified in paragraph (h)(6)(ii) of this section must be tracked separately but reported as a single set of values as specified in paragraph (e)(1)(iii) of this section.

(iv) *Catalyst system MIL activation and DTC storage.* (A) The MIL must activate and DTCs must be stored according to the provisions of paragraph (b) of this section.

(B) The monitoring method for the catalyst system must be capable of detecting when a catalyst DTC has been erased (except OBD system self erase), but the catalyst has not been replaced (e.g., catalyst overtemperature histogram approaches are not acceptable).

(7) *Evaporative system monitoring—(i) General.* The OBD system must verify purge flow from the evaporative system and monitor the complete evaporative system, excluding the tubing and connections between the purge valve and the intake manifold, for vapor leaks to the atmosphere. Individual components of the evaporative system (e.g. valves, sensors) must be monitored in accordance with the comprehensive components requirements in paragraph (i)(3) of this section.

(ii) *Evaporative system malfunction criteria—(A) Purge monitor.* The OBD system must detect an evaporative system malfunction when no purge flow from the evaporative system to the engine can be detected by the OBD system.

(B) *Leak monitor.* The OBD system must detect an evaporative system malfunction when the complete evaporative system contains a leak or leaks that cumulatively are greater than or equal to a leak caused by a 0.150 inch diameter hole.

(C) The manufacturer may demonstrate that detection of a larger hole is more appropriate than that specified in paragraph (h)(7)(ii)(B) of this section. To do so, the manufacturer must demonstrate through data and/or engineering analyses that holes smaller than the proposed detection size would not result in evaporative or running loss emissions that exceed 1.5 times the applicable evaporative emissions standards. Upon such a demonstration,



the proposed detection size could be substituted for the requirement of paragraph (h)(7)(ii)(B) of this section.

(iii) *Evaporative system monitoring conditions.* (A) The manufacturer must define monitoring conditions for malfunctions identified in paragraph (h)(7)(ii)(A) of this section in accordance with paragraphs (c) and (d) of this section.

(B) The manufacturer must define monitoring conditions for malfunctions identified in paragraph (h)(7)(ii)(B) of this section in accordance with paragraphs (c) and (d) of this section. For purposes of tracking and reporting as required by paragraph (d)(1) of this section, all monitors used to detect malfunctions identified in paragraph (h)(7)(ii)(B) of this section must be tracked separately but reported as a single set of values as specified in paragraph (e)(1)(iii) of this section.

(C) The manufacturer may disable or abort an evaporative system monitor when the fuel tank level is over 85 percent of nominal tank capacity or during a refueling event.

(D) The manufacturer may request Administrator approval to run the evaporative system monitor during only those drive cycles characterized as cold starts provided such a condition is needed to ensure reliable monitoring. In making the request, the manufacturer must demonstrate through data and/or engineering analyses that a reliable monitor can only be run on drive cycles that begin with a specific set of cold start criteria. A set of cold start criteria based solely on ambient temperature exceeding engine coolant temperature will not be acceptable.

(E) The OBD system may disable temporarily the evaporative purge system to run an evaporative system leak monitor.

(iv) *Evaporative system MIL activation and DTC storage.* (A) Except as provided for in paragraph (h)(7)(iv)(B) of this section, the MIL must activate and DTCs must be stored according to the provisions of paragraph (b) of this section.

(B) If the OBD system is capable of discerning that a system leak is being caused by a missing or improperly se-

cured gas cap, the OBD system need not activate the MIL or store a DTC provided the vehicle is equipped with an alternative indicator for notifying the operator of the gas cap problem. The alternative indicator must be of sufficient illumination and location to be readily visible under all lighting conditions. If the vehicle is not equipped with such an alternative indicator, the MIL must activate and a DTC be stored as required in paragraph (h)(7)(iv)(A) of this section; however, these may be deactivated and erased, respectively, if the OBD system determines that the gas cap problem has been corrected and the MIL has not been activated for any other malfunction. The Administrator may approve other strategies that provide equivalent assurance that a vehicle operator will be notified promptly of a missing or improperly secured gas cap and that corrective action will be undertaken.

(8) *Exhaust gas sensor monitoring—(i) General.* (A) The OBD system must monitor for malfunctions the output signal, response rate, and any other parameter that can affect emissions of all primary (i.e., fuel control) exhaust gas sensors (e.g., oxygen, wide-range air/fuel). Both the lean-to-rich and rich-to-lean response rates must be monitored.

(B) The OBD system must also monitor all secondary exhaust gas sensors (those used for secondary fuel trim control or as a monitoring device) for proper output signal, activity, and response rate.

(C) For engines equipped with heated exhaust gas sensor, the OBD system must monitor the heater for proper performance.

(ii) *Primary exhaust gas sensor malfunction criteria.* (A) The OBD system must detect a malfunction prior to any failure or deterioration of the exhaust gas sensor output voltage, resistance, impedance, current, response rate, amplitude, offset, or other characteristic(s) (including drift or bias corrected for by secondary sensors) that would cause an engine's emissions to exceed the emissions thresholds for "other monitors" as shown in Table 2 of this paragraph (h).

(B) The OBD system must detect malfunctions of the exhaust gas sensor

caused by either a lack of circuit continuity or out-of-range values.

(C) The OBD system must detect a malfunction of the exhaust gas sensor when a sensor failure or deterioration causes the fuel system to stop using that sensor as a feedback input (e.g., causes default or open-loop operation).

(D) The OBD system must detect a malfunction of the exhaust gas sensor when the sensor output voltage, resistance, impedance, current, amplitude, activity, or other characteristics are no longer sufficient for use as an OBD system monitoring device (e.g., for catalyst monitoring).

(iii) *Secondary exhaust gas sensor malfunction criteria.* (A) The OBD system must detect a malfunction prior to any failure or deterioration of the exhaust gas sensor voltage, resistance, impedance, current, response rate, amplitude, offset, or other characteristic(s) that would cause an engine's emissions to exceed the emissions thresholds for "other monitors" as shown in Table 2 of this paragraph (h).

(B) The OBD system must detect malfunctions of the exhaust gas sensor caused by a lack of circuit continuity.

(C) To the extent feasible, the OBD system must detect a malfunction of the exhaust gas sensor when the sensor output voltage, resistance, impedance, current, amplitude, activity, offset, or other characteristics are no longer sufficient for use as an OBD system monitoring device (e.g., for catalyst monitoring).

(D) The OBD system must detect malfunctions of the exhaust gas sensor caused by out-of-range values.

(E) The OBD system must detect a malfunction of the exhaust gas sensor when a sensor failure or deterioration causes the fuel system (e.g., fuel control) to stop using that sensor as a feedback input (e.g., causes default or open-loop operation).

(iv) *Exhaust gas sensor heater malfunction criteria.* (A) The OBD system must detect a malfunction of the heater performance when the current or voltage drop in the heater circuit is no longer within the manufacturer's specified limits for normal operation (i.e., within the criteria required to be met by the component vendor for heater circuit performance at high mileage).

Other malfunction criteria for heater performance malfunctions may be used upon demonstrating via data or engineering analyses that the monitoring reliability and timeliness is equivalent to the stated criteria in this paragraph (h)(8)(iv)(A).

(B) The OBD system must detect malfunctions of the heater circuit including open or short circuits that conflict with the commanded state of the heater (e.g., shorted to 12 Volts when commanded to 0 Volts (ground)).

(v) *Primary exhaust gas sensor monitoring conditions.* (A) The manufacturer must define monitoring conditions for malfunctions identified in paragraphs (h)(8)(ii)(A) and (h)(8)(ii)(D) of this section in accordance with paragraphs (c) and (d) of this section. For purposes of tracking and reporting as required by paragraph (d)(1) of this section, all monitors used to detect malfunctions identified in paragraphs (h)(8)(ii)(A) and (h)(8)(ii)(D) of this section must be tracked separately but reported as a single set of values as specified in paragraph (e)(1)(iii) of this section.

(B) Except as provided for in paragraph (h)(8)(v)(C) of this section, monitoring for malfunctions identified in paragraphs (h)(8)(ii)(B) and (h)(8)(ii)(C) of this section must be conducted continuously.

(C) The manufacturer may disable continuous primary exhaust gas sensor monitoring when a primary exhaust gas sensor malfunction cannot be distinguished from other effects (e.g., disable out-of-range low monitoring during fuel cut conditions). To do so, the manufacturer must demonstrate via data or engineering analyses that a properly functioning sensor cannot be distinguished from a malfunctioning sensor and that the disablement interval is limited only to that necessary for avoiding false detection.

(vi) *Secondary exhaust gas sensor monitoring conditions.* (A) The manufacturer must define monitoring conditions for malfunctions identified in paragraphs (h)(8)(iii)(A) through (h)(8)(iii)(C) of this section in accordance with paragraphs (c) and (d) of this section.

(B) Except as provided for in paragraph (h)(8)(vi)(C) of this section, monitoring for malfunctions identified in paragraphs (h)(8)(iii)(D) and

(h)(8)(iii)(E) of this section must be conducted continuously.

(C) The manufacturer may disable continuous secondary exhaust gas sensor monitoring when a secondary exhaust gas sensor malfunction cannot be distinguished from other effects (e.g., disable out-of-range low monitoring during fuel cut conditions). To do so, the manufacturer must demonstrate via data or engineering analyses that a properly functioning sensor cannot be distinguished from a malfunctioning sensor and that the disablement interval is limited only to that necessary for avoiding false detection.

(vii) *Exhaust gas sensor heater monitoring conditions.* (A) The manufacturer must define monitoring conditions for malfunctions identified in paragraph (h)(8)(iv)(A) of this section in accordance with paragraphs (c) and (d) of this section.

(B) Monitoring for malfunctions identified in paragraph (h)(8)(iv)(B) of this section must be conducted continuously.

(viii) *Exhaust gas sensor MIL activation and DTC storage.* The MIL must activate and DTCs must be stored according to the provisions of paragraph (b) of this section.

(9) *Variable valve timing (VVT) system monitoring—(i) General.* The OBD system must monitor the VVT system on engines so equipped for target error and slow response malfunctions. The individual electronic components (e.g., actuators, valves, sensors) that are used in the VVT system must be monitored in accordance with the comprehensive components requirements in paragraph (i)(3).

(ii) *VVT system malfunction criteria—(A) VVT system target error.* The OBD system must detect a malfunction prior to any failure or deterioration in the capability of the VVT system to achieve the commanded valve timing and/or control within a crank angle and/or lift tolerance that would cause an engine's emissions to exceed the emission thresholds for "other monitors" as shown in Table 2 of this paragraph (h).

(B) *VVT slow response.* The OBD system must detect a malfunction prior to any failure or deterioration in the capability of the VVT system to achieve

the commanded valve timing and/or control within a manufacturer-specified time that would cause an engine's emissions to exceed the emission thresholds for "other monitors" as shown in Table 2 of this paragraph (h).

(C) For engines in which no failure or deterioration of the VVT system could result in an engine's emissions exceeding the applicable emissions thresholds of paragraphs (h)(9)(ii)(A) and (h)(9)(ii)(B) of this section, the OBD system must detect a malfunction of the VVT system when proper functional response of the system to computer commands does not occur.

(iii) *VVT system monitoring conditions.* Manufacturers must define the monitoring conditions for VVT system malfunctions identified in paragraph (h)(9)(ii) in accordance with paragraphs (c) and (d) of this section, with the exception that monitoring must occur every time the monitoring conditions are met during the drive cycle rather than once per drive cycle as required in paragraph (c)(2) of this section. For purposes of tracking and reporting as required in paragraph (d)(1) of this section, all monitors used to detect malfunctions identified in paragraph (h)(9)(ii) must be tracked separately but reported as a single set of values as specified in paragraph (e)(1)(iii) of this section.

(iv) *VVT MIL activation and DTC storage.* The MIL must activate and DTCs must be stored according to the provisions of paragraph (b) of this section.

(i) *OBD monitoring requirements for all engines—(1) Engine cooling system monitoring—(i) General.* (A) The OBD system must monitor the thermostat on engines so equipped for proper operation.

(B) The OBD system must monitor the engine coolant temperature (ECT) sensor for electrical circuit continuity, out-of-range values, and rationality malfunctions.

(C) For engines that use a system other than the cooling system and ECT sensor (e.g., oil temperature, cylinder head temperature) to determine engine operating temperature for emission control purposes (e.g., to modify spark or fuel injection timing or quantity), the manufacturer may forego cooling system monitoring and instead monitor the components or systems used in

their approach. To do so, the manufacturer must submit data and/or engineering analyses that demonstrate that their monitoring plan is as reliable and effective as the monitoring required in this paragraph (i)(1).

(ii) *Malfunction criteria for the thermostat.* (A) The OBD system must detect a thermostat malfunction if, within the manufacturer specified time interval following engine start, any of the following conditions occur: The coolant temperature does not reach the highest temperature required by the OBD system to enable other diagnostics; and, the coolant temperature does not reach a warmed-up temperature within 20 degrees Fahrenheit of the manufacturer's nominal thermostat regulating temperature. For the second of these two conditions, the manufacturer may use a lower temperature for this criterion if either the manufacturer can demonstrate that the fuel, spark timing, and/or other coolant temperature-based modification to the engine control strategies would not cause an emissions increase greater than or equal to 50 percent of any of the applicable emissions standards; or, ambient air temperature is between 20 degrees Fahrenheit and 50 degrees Fahrenheit in which case, upon Administrator approval, the minimum coolant temperature required to be reached may be decreased based on the ambient air temperature.

(B) With Administrator approval, the manufacturer may use alternative malfunction criteria to those of paragraph (i)(1)(ii)(A) of this section and/or alternative monitoring conditions to those of paragraph (i)(1)(iv) of this section that are a function of temperature at engine start on engines that do not reach the temperatures specified in the malfunction criteria when the thermostat is functioning properly. To do so, the manufacturer is required to submit data and/or engineering analyses that demonstrate that a properly operating system does not reach the specified temperatures and that the possibility is minimized for cooling system malfunctions to go undetected thus disabling other OBD monitors.

(C) The manufacturer may request Administrator approval to forego monitoring of the thermostat if the manu-

facturer can demonstrate that a malfunctioning thermostat cannot cause a measurable increase in emissions during any reasonable driving condition nor cause any disablement of other OBD monitors.

(iii) *Malfunction criteria for the ECT sensor—(A) Circuit integrity.* The OBD system must detect malfunctions of the ECT sensor related to a lack of circuit continuity or out-of-range values.

(B) *Time to reach closed-loop/feedback enable temperature.* The OBD system must detect if, within the manufacturer specified time interval following engine start, the ECT sensor does not achieve the highest stabilized minimum temperature that is needed to initiate closed-loop/feedback control of all affected emission control systems (e.g., fuel system, EGR system). The manufacturer specified time interval must be a function of the engine coolant temperature and/or intake air temperature at startup. The manufacturer time interval must be supported by data and/or engineering analyses demonstrating that it provides robust monitoring and minimizes the likelihood of other OBD monitors being disabled. The manufacturer may forego the requirements of this paragraph (i)(1)(iii)(B) provided the manufacturer does not use engine coolant temperature or the ECT sensor to enable closed-loop/feedback control of any emission control systems.

(C) *Stuck in range below the highest minimum enable temperature.* To the extent feasible when using all available information, the OBD system must detect a malfunction if the ECT sensor inappropriately indicates a temperature below the highest minimum enable temperature required by the OBD system to enable other monitors (e.g., an OBD system that requires ECT to be greater than 140 degrees Fahrenheit to enable a diagnostic must detect malfunctions that cause the ECT sensor to inappropriately indicate a temperature below 140 degrees Fahrenheit). The manufacturer may forego this requirement for temperature regions in which the monitors required under paragraphs (i)(1)(ii) or (i)(1)(iii)(B) of this section will detect ECT sensor malfunctions as defined in this paragraph (i)(1)(iii)(C).

(D) *Stuck in range above the lowest maximum enable temperature.* The OBD system must detect a malfunction if the ECT sensor inappropriately indicates a temperature above the lowest maximum enable temperature required by the OBD system to enable other monitors (e.g., an OBD system that requires an engine coolant temperature less than 90 degrees Fahrenheit at startup prior to enabling an OBD monitor must detect malfunctions that cause the ECT sensor to indicate inappropriately a temperature above 90 degrees Fahrenheit). The manufacturer may forego this requirement within temperature regions in which the monitors required under paragraphs (i)(1)(ii), (i)(1)(iii)(B), (i)(1)(iii)(C) of this section will detect ECT sensor malfunctions as defined in this paragraph (i)(1)(iii)(D) or in which the MIL will be activated according to the provisions of paragraph (b)(2)(v) of this section. The manufacturer may also forego this monitoring within temperature regions where a temperature gauge on the instrument panel indicates a temperature in the "red zone" (engine overheating zone) and displays the same temperature information as used by the OBD system.

(iv) *Monitoring conditions for the thermostat.* (A) The manufacturer must define the monitoring conditions for malfunctions identified in paragraph (i)(1)(ii)(A) of this section in accordance with paragraph (c) of this section. Additionally, except as provided for in paragraphs (i)(1)(iv)(B) and (i)(1)(iv)(C) of this section, monitoring for malfunctions identified in paragraph (i)(1)(ii)(A) of this section must be conducted once per drive cycle on every drive cycle in which the ECT sensor indicates, at engine start, a temperature lower than the temperature established as the malfunction criteria in paragraph (i)(1)(ii)(A) of this section.

(B) The manufacturer may disable thermostat monitoring at ambient engine start temperatures below 20 degrees Fahrenheit.

(C) The manufacturers may request Administrator approval to suspend or disable thermostat monitoring if the engine is subjected to conditions that could lead to false diagnosis. To do so, the manufacturer must submit data

and/or engineering analyses that demonstrate that the suspension or disablement is necessary. In general, the manufacturer will not be allowed to suspend or disable the thermostat monitor on engine starts where the engine coolant temperature at engine start is more than 35 degrees Fahrenheit lower than the thermostat malfunction threshold temperature determined under paragraph (i)(1)(ii)(A) of this section.

(v) *Monitoring conditions for the ECT sensor.* (A) Except as provided for in paragraph (i)(1)(v)(D) of this section, the OBD system must monitor continuously for malfunctions identified in paragraph monitoring for malfunctions identified in paragraph (i)(1)(iii)(A) of this section (i.e., circuit integrity and out-of-range).

(B) The manufacturer must define the monitoring conditions for malfunctions identified in paragraph (i)(1)(iii)(B) of this section in accordance with paragraph (c) of this section. Additionally, except as provided for in paragraph (i)(1)(v)(D) of this section, monitoring for malfunctions identified in paragraph (i)(1)(iii)(B) of this section must be conducted once per drive cycle on every drive cycle in which the ECT sensor indicates a temperature lower than the closed-loop enable temperature at engine start (i.e., all engine start temperatures greater than the ECT sensor out-of-range low temperature and less than the closed-loop enable temperature).

(C) The manufacturer must define the monitoring conditions for malfunctions identified in paragraphs (i)(1)(iii)(C) and (i)(1)(iii)(D) of this section in accordance with paragraphs (c) and (d) of this section.

(D) The manufacturer may suspend or delay the monitor for the time to reach closed-loop enable temperature if the engine is subjected to conditions that could lead to false diagnosis (e.g., vehicle operation at idle for more than 50 to 75 percent of the warm-up time).

(E) The manufacturer may request Administrator approval to disable continuous ECT sensor monitoring when an ECT sensor malfunction cannot be distinguished from other effects. To do so, the manufacturer must submit data

and/or engineering analyses that demonstrate a properly functioning sensor cannot be distinguished from a malfunctioning sensor and that the disablement interval is limited only to that necessary for avoiding false detection.

(vi) *Engine cooling system MIL activation and DTC storage.* The MIL must activate and DTCs must be stored according to the provisions of paragraph (b) of this section.

(2) *Crankcase ventilation (CV) system monitoring*—(i) *General.* The OBD system must monitor the CV system on engines so equipped for system integrity. Engines not required to be equipped with CV systems are exempt from monitoring the CV system. For diesel engines, the manufacturer must submit a plan for Administrator approval prior to OBD certification. That plan must include descriptions of the monitoring strategy, malfunction criteria, and monitoring conditions for CV system monitoring. The plan must demonstrate that the CV system monitor is of equivalent effectiveness, to the extent feasible, to the malfunction criteria and the monitoring conditions of this paragraph (i)(2).

(ii) *Crankcase ventilation system malfunction criteria.* (A) For the purposes of this paragraph (i)(2), “CV system” is defined as any form of crankcase ventilation system, regardless of whether it utilizes positive pressure. “CV valve” is defined as any form of valve or orifice used to restrict or control crankcase vapor flow. Further, any additional external CV system tubing or hoses used to equalize crankcase pressure or to provide a ventilation path between various areas of the engine (e.g., crankcase and valve cover) are considered part of the CV system “between the crankcase and the CV valve” and subject to the malfunction criteria in paragraph (i)(2)(ii)(B) of this section.

(B) Except as provided for in paragraphs (i)(2)(ii)(C) through (i)(2)(ii)(E) of this section, the OBD system must detect a malfunction of the CV system when a disconnection of the system occurs between either the crankcase and the CV valve, or between the CV valve and the intake manifold.

(C) The manufacturer may forego monitoring for a disconnection be-

tween the crankcase and the CV valve provided the CV system is designed such that the CV valve is fastened directly to the crankcase such that it is significantly more difficult to remove the CV valve from the crankcase than to disconnect the line between the CV valve and the intake manifold (taking aging effects into consideration). To do so, the manufacturer must be able to provide data and/or an engineering evaluation demonstrating that the CV system is so designed.

(D) The manufacturer may forego monitoring for a disconnection between the crankcase and the CV valve provided the CV system is designed such that it uses tubing connections between the CV valve and the crankcase that are: resistant to deterioration or accidental disconnection; significantly more difficult to disconnect than is the line between the CV valve and the intake manifold; and, not subject to disconnection per the manufacturer’s repair procedures for any non-CV system repair. To do so, the manufacturer must be able to provide data and/or engineering evaluation demonstrating that the CV system is so designed.

(E) The manufacturer may forego monitoring for a disconnection between the CV valve and the intake manifold provided the CV system is designed such that any disconnection either causes the engine to stall immediately during idle operation, or is unlikely to occur due to a CV system design that is integral to the induction system (e.g., machined passages rather than tubing or hoses). To do so, the manufacturer must be able to provide data and/or an engineering evaluation demonstrating that the CV system is so designed.

(iii) *Crankcase ventilation system monitoring conditions.* The manufacturer must define the monitoring conditions for malfunctions identified in paragraph (i)(2) of this section in accordance with paragraphs (c) and (d) of this section.

(iv) *Crankcase ventilation system MIL activation and DTC storage.* The MIL must activate and DTCs must be stored according to the provisions of paragraph (b) of this section. The stored DTC need not identify specifically the

CV system (e.g., a DTC for idle speed control or fuel system monitoring can be stored) if the manufacturer can demonstrate that additional monitoring hardware is necessary to make such an identification and provided the manufacturer's diagnostic and repair procedures for the detected malfunction include directions to check the integrity of the CV system.

(3) *Comprehensive component monitoring*—(i) *General*. Except as provided for in paragraph (i)(4) of this section, the OBD system must detect a malfunction of any electronic engine component or system not otherwise described in paragraphs (g), (h), (i)(1), and (i)(2) of this section that either provides input to (directly or indirectly, such components may include the crank angle sensor, knock sensor, throttle position sensor, cam position sensor, intake air temperature sensor, boost pressure sensor, manifold pressure sensor, mass air flow sensor, exhaust temperature sensor, exhaust pressure sensor, fuel pressure sensor, fuel composition sensor of a flexible fuel vehicle, etc.) or receives commands from (such components or systems may include the idle speed control system, glow plug system, variable length intake manifold runner systems, supercharger or turbocharger electronic components, heated fuel preparation systems, the wait-to-start lamp on diesel applications, the MIL, etc.) the onboard computer(s) and meets either of the criteria described in paragraphs (i)(3)(i)(A) and/or (i)(3)(i)(B) of this section. Note that, for the purposes of this paragraph (i)(3), “electronic engine component or system” does not include components that are driven by the engine and are not related to the control of the fueling, air handling, or emissions of the engine (e.g., PTO components, air conditioning system components, and power steering components).

(A) It can cause emissions to exceed applicable emission standards. To preclude monitoring, the manufacturer must be able to provide emission data showing that the component or system, when malfunctioning and installed on a suitable test engine, does not cause emissions to exceed the emission standards.

(B) It is used as part of the monitoring strategy for any other monitored system or component.

(ii) *Comprehensive component malfunction criteria for input components*. (A) The OBD system must detect malfunctions of input components caused by a lack of circuit continuity and out-of-range values. In addition, where feasible, rationality checks must also be done and shall verify that a sensor output is neither inappropriately high nor inappropriately low (i.e., “two-sided” monitoring).

(B) To the extent feasible, the OBD system must separately detect and store different DTCs that distinguish rationality malfunctions from lack of circuit continuity and out-of-range malfunctions. For lack of circuit continuity and out-of-range malfunctions, the OBD system must, to the extent feasible, separately detect and store different DTCs for each distinct malfunction (e.g., out-of-range low, out-of-range high, open circuit). The OBD system is not required to store separate DTCs for lack of circuit continuity malfunctions that cannot be distinguished from other out-of-range circuit malfunctions.

(C) For input components that are used to activate alternative strategies that can affect emissions (e.g., AECDs, engine shutdown systems), the OBD system must conduct rationality checks to detect malfunctions that cause the system to activate erroneously or deactivate the alternative strategy. To the extent feasible when using all available information, the rationality check must detect a malfunction if the input component inappropriately indicates a value that activates or deactivates the alternative strategy. For example, for an alternative strategy that activates when the intake air temperature is greater than 120 degrees Fahrenheit, the OBD system must detect malfunctions that cause the intake air temperature sensor to indicate inappropriately a temperature above 120 degrees Fahrenheit.

(D) For engines that require precise alignment between the camshaft and the crankshaft, the OBD system must monitor the crankshaft position sensor(s) and camshaft position sensor(s) to verify proper alignment between the

camshaft and crankshaft in addition to monitoring the sensors for circuit continuity and proper rationality. Proper alignment monitoring between a camshaft and a crankshaft is required only in cases where both are equipped with position sensors. For engines equipped with VVT systems and a timing belt or chain, the OBD system must detect a malfunction if the alignment between the camshaft and crankshaft is off by one or more cam/crank sprocket cogs (e.g., the timing belt/chain has slipped by one or more teeth/cogs). If a manufacturer demonstrates that a single tooth/cog misalignment cannot cause a measurable increase in emissions during any reasonable driving condition, the OBD system must detect a malfunction when the minimum number of teeth/cogs misalignment has occurred that does cause a measurable emission increase.

(iii) *Comprehensive component malfunction criteria for output components/systems.* (A) The OBD system must detect a malfunction of an output component/system when proper functional response does not occur in response to computer commands. If such a functional check is not feasible, the OBD system must detect malfunctions of output components/systems caused by a lack of circuit continuity or circuit malfunction (e.g., short to ground or high voltage). For output component lack of circuit continuity malfunctions and circuit malfunctions, the OBD system is not required to store different DTCs for each distinct malfunction (e.g., open circuit, shorted low). Manufacturers are not required to activate an output component/system when it would not normally be active for the sole purpose of performing a functional check of it as required in this paragraph (i)(3).

(B) For gasoline engines, the idle control system must be monitored for proper functional response to computer commands. For gasoline engines using monitoring strategies based on deviation from target idle speed, a malfunction must be detected when either of the following conditions occurs: The idle speed control system cannot achieve the target idle speed within 200 revolutions per minute (rpm) above the target speed or 100 rpm below the tar-

get speed; or, the idle speed control system cannot achieve the target idle speed within the smallest engine speed tolerance range required by the OBD system to enable any other monitors. Regarding the former of these conditions, the manufacturer may use larger engine speed tolerances. To do so, the manufacturer must be able to provide data and/or engineering analyses that demonstrate that the tolerances can be exceeded without a malfunction being present.

(C) For diesel engines, the idle control system must be monitored for proper functional response to computer commands. For diesel engines, a malfunction must be detected when either of the following conditions occurs: the idle fuel control system cannot achieve the target idle speed or fuel injection quantity within  $\pm 50$  percent of the manufacturer-specified fuel quantity and engine speed tolerances; or, the idle fuel control system cannot achieve the target idle speed or fueling quantity within the smallest engine speed or fueling quantity tolerance range required by the OBD system to enable any other monitors.

(D) For model years 2010 through 2012, glow plugs must be monitored for circuit continuity malfunctions. For model years 2010 and later, intake air heater systems and, for model years 2013 and later, glow plugs must be monitored for proper functional response to computer commands and for circuit continuity malfunctions. The glow plug/intake air heater circuit(s) must be monitored for proper current and voltage drop. The manufacturer may use other monitoring strategies but must be able to provide data and/or engineering analyses that demonstrate reliable and timely detection of malfunctions. The OBD system must also detect a malfunction when a single glow plug no longer operates within the manufacturer's specified limits for normal operation. If a manufacturer can demonstrate that a single glow plug malfunction cannot cause a measurable increase in emissions during any reasonable driving condition, the OBD system must instead detect a malfunction when the number of glow plugs needed to cause an emission increase is malfunctioning. To the extent feasible,



the stored DTC must identify the specific malfunctioning glow plug(s).

(E) The wait-to-start lamp circuit and the MIL circuit must be monitored for malfunctions that cause either lamp to fail to activate when commanded to do so (e.g., burned out bulb). This monitoring of the wait-to-start lamp circuit and the MIL circuit is not required for wait-to-start lamps and MILs using light-emitting diodes (LEDs).

(iv) *Monitoring conditions for input components.* (A) The OBD system must monitor input components continuously for out-of-range values and circuit continuity. The manufacturer may disable continuous monitoring for circuit continuity and out-of-range values when a malfunction cannot be distinguished from other effects. To do so, the manufacturer must be able to provide data and/or engineering analyses that demonstrate that a properly functioning input component cannot be distinguished from a malfunctioning input component and that the disablement interval is limited only to that necessary for avoiding false malfunction detection.

(B) For input component rationality checks (where applicable), the manufacturer must define the monitoring conditions for detecting malfunctions in accordance with paragraphs (c) and (d) of this section, with the exception that rationality checks must occur every time the monitoring conditions are met during the drive cycle rather than once per drive cycle as required in paragraph (c)(2) of this section.

(v) *Monitoring conditions for output components/systems.* (A) The OBD system must monitor output components/systems continuously for circuit continuity and circuit malfunctions. The manufacturer may disable continuous monitoring for circuit continuity and circuit malfunctions when a malfunction cannot be distinguished from other effects. To do so, the manufacturer must be able to provide data and/or engineering analyses that demonstrate that a properly functioning output component/system cannot be distinguished from a malfunctioning one and that the disablement interval is limited only to that necessary for avoiding false malfunction detection.

(B) For output component/system functional checks, the manufacturer must define the monitoring conditions for detecting malfunctions in accordance with paragraphs (c) and (d) of this section. Specifically for the idle control system, the manufacturer must define the monitoring conditions for detecting malfunctions in accordance with paragraphs (c) and (d) of this section, with the exception that functional checks must occur every time the monitoring conditions are met during the drive cycle rather than once per drive cycle as required in paragraph (c)(2) of this section.

(vi) *Comprehensive component MIL activation and DTC storage.* (A) Except as provided for in paragraphs (i)(3)(vi)(B) and (i)(3)(vi)(C) of this section, the MIL must activate and DTCs must be stored according to the provisions of paragraph (b) of this section.

(B) The MIL need not be activated in conjunction with storing a MIL-on DTC for any comprehensive component if: the component or system, when malfunctioning, could not cause engine emissions to increase by 15 percent or more of the applicable FTP standard during any reasonable driving condition; or, the component or system is not used as part of the monitoring strategy for any other system or component that is required to be monitored.

(C) The MIL need not be activated if a malfunction has been detected in the MIL circuit that prevents the MIL from activating (e.g., burned out bulb or light-emitting diode, LED). Nonetheless, the electronic MIL status (see paragraph (k)(4)(ii) of this section) must be reported as MIL commanded-on and a MIL-on DTC must be stored.

(4) *Other emission control system monitoring*—(i) *General.* For other emission control systems that are either not addressed in paragraphs (g) through (i)(3) of this section (e.g., hydrocarbon traps, homogeneous charge compression ignition control systems), or addressed in paragraph (i)(3) of this section but not corrected or compensated for by an adaptive control system (e.g., swirl control valves), the manufacturer must

submit a plan for Administrator approval of the monitoring strategy, malfunction criteria, and monitoring conditions prior to introduction on a production engine. The plan must demonstrate the effectiveness of the monitoring strategy, the malfunction criteria used, the monitoring conditions required by the monitor, and, if applicable, the determination that the requirements of paragraph (i)(4)(ii) of this section are satisfied.

(ii) For engines that use emission control systems that alter intake air flow or cylinder charge characteristics by actuating valve(s), flap(s), etc., in the intake air delivery system (e.g., swirl control valve systems), the manufacturer, in addition to meeting the requirements of paragraph (i)(4)(i) of this section, may elect to have the OBD system monitor the shaft to which all valves in one intake bank are physically attached rather than performing a functional check of the intake air flow, cylinder charge, or individual valve(s)/flap(s). For non-metal shafts or segmented shafts, the monitor must verify all shaft segments for proper functional response (e.g., by verifying that the segment or portion of the shaft farthest from the actuator functions properly). For systems that have more than one shaft to operate valves in multiple intake banks, the manufacturer is not required to add more than one set of detection hardware (e.g., sensor, switch) per intake bank to meet this requirement.

(5) *Exceptions to OBD monitoring requirements.* (i) The Administrator may revise the PM filtering performance malfunction criteria for DPFs to exclude detection of specific failure modes such as partially melted substrates, if the most reliable monitoring method developed requires it.

(ii) The manufacturer may disable an OBD system monitor at ambient engine start temperatures below 20 degrees Fahrenheit (low ambient temperature conditions may be determined based on intake air or engine coolant temperature at engine start) or at elevations higher than 8,000 feet above sea level. To do so, the manufacturer must submit data and/or engineering analyses that demonstrate that monitoring is unreliable during the disable condi-

tions. A manufacturer may request that an OBD system monitor be disabled at other ambient engine start temperatures by submitting data and/or engineering analyses demonstrating that misdiagnosis would occur at the given ambient temperatures due to their effect on the component itself (e.g., component freezing).

(iii) The manufacturer may disable an OBD system monitor when the fuel level is 15 percent or less of the nominal fuel tank capacity for those monitors that can be affected by low fuel level or running out of fuel (e.g., misfire detection). To do so, the manufacturer must submit data and/or engineering analyses that demonstrate that monitoring at the given fuel levels is unreliable, and that the OBD system is still able to detect a malfunction if the component(s) used to determine fuel level indicates erroneously a fuel level that causes the disablement.

(iv) The manufacturer may disable OBD monitors that can be affected by engine battery or system voltage levels.

(A) For an OBD monitor affected by low vehicle battery or system voltages, manufacturers may disable monitoring when the battery or system voltage is below 11.0 Volts. The manufacturer may use a voltage threshold higher than 11.0 Volts to disable monitors but must submit data and/or engineering analyses that demonstrate that monitoring at those voltages is unreliable and that either operation of a vehicle below the disablement criteria for extended periods of time is unlikely or the OBD system monitors the battery or system voltage and will detect a malfunction at the voltage used to disable other monitors.

(B) For an OBD monitor affected by high engine battery or system voltages, the manufacturer may disable monitoring when the battery or system voltage exceeds a manufacturer-defined voltage. To do so, the manufacturer must submit data and/or engineering analyses that demonstrate that monitoring above the manufacturer-defined voltage is unreliable and that either the electrical charging system/alternator warning light will be activated (or voltage gauge would be in the "red zone") or the OBD system

monitors the battery or system voltage and will detect a malfunction at the voltage used to disable other monitors.

(v) The manufacturer may also disable affected OBD monitors in systems designed to accommodate the installation of power take off (PTO) units provided monitors are disabled only while the PTO unit is active and the OBD readiness status (see paragraph (k)(4)(i) of this section) is cleared by the on-board computer (i.e., all monitors set to indicate “not complete” or “not ready”) while the PTO unit is activated. If monitors are so disabled and when the disablement ends, the readiness status may be restored to its state prior to PTO activation.

(6) *Feedback control system monitoring.* If the engine is equipped with feedback control of any of the systems covered in paragraphs (g), (h) and (i) of this section, then the OBD system must detect as malfunctions the conditions specified in this paragraph (i)(6) for each of the individual feedback controls.

(i) The OBD system must detect when the system fails to begin feedback control within a manufacturer specified time interval.

(ii) When any malfunction or deterioration causes open loop or limp-home operation.

(iii) When feedback control has used up all of the adjustment allowed by the manufacturer.

(iv) A manufacturer may temporarily disable monitoring for malfunctions specified in paragraph (i)(6)(iii) of this section during conditions that the specific monitor cannot distinguish robustly between a malfunctioning system and a properly operating system. To do so, the manufacturer is required to submit data and/or engineering analyses demonstrating that the individual feedback control system, when operating as designed on an engine with all emission controls working properly, routinely operates during these conditions while having used up all of the adjustment allowed by the manufacturer. In lieu of detecting, with a system specific monitor, the malfunctions specified in paragraphs (i)(6)(i) and (i)(6)(ii) of this section the OBD system may monitor the individual parameters or components that are used as inputs for individual feedback control systems

provided that the monitors detect all malfunctions that meet the criteria of paragraphs (i)(6)(i) and (i)(6)(ii) of this section.

(j) *Production evaluation testing—(1) Verification of standardization requirements.* (i) For model years 2013 and later, the manufacturer must perform testing to verify that production vehicles meet the requirements of paragraphs (k)(3) and (k)(4) of this section relevant to the proper communication of required emissions-related messages to a SAE J1978 or SAE J1939 (both as specified in paragraph (k)(1) of this section) scan tool.

(ii) *Selection of test vehicles.* (A) The manufacturer must perform this testing every model year on ten unique production vehicles (i.e., engine rating and chassis application combination) per engine family. If there are less than ten unique production vehicles for a certain engine family, the manufacturer must test each unique production vehicle in that engine family. The manufacturer must perform this testing within either three months of the start of engine production or one month of the start of vehicle production, whichever is later. The manufacturer may request approval to group multiple production vehicles together and test one representative vehicle per group. To do so, the software and hardware designed to comply with the standardization requirements of paragraph (k)(1) of this section (e.g., communication protocol message timing, number of supported data stream parameters, engine and vehicle communication network architecture) in the representative vehicle must be identical to all others in the group and any differences in the production vehicles cannot be relevant with respect to meeting the criteria of paragraph (j)(1)(iv) of this section.

(B) For 2016 and subsequent model years, the required number of vehicles to be tested shall be reduced to five per engine family provided zero vehicles fail the testing required by paragraph (j)(1) of this section for two consecutive years.

(C) For 2019 and subsequent model years, the required number of vehicles to be tested shall be reduced to three

per engine family provided zero vehicles fail the testing required by paragraph (j)(1) of this section for three consecutive years.

(D) The requirement for submittal of data from one or more of the production vehicles shall be waived if data have been submitted previously for all of the production vehicles. The manufacturer may request approval to carry over data collected in previous model years. To do so, the software and hardware designed to comply with the standardization requirements of paragraph (k)(1) of this section must be identical to the previous model year and there must not have been other hardware or software changes that affect compliance with the standardization requirements.

(E) For hybrid engine families with projected U.S.-directed production volume of less than 5,000 engines, the manufacturers are only required to test one engine-hybrid combination per family.

(iii) *Test equipment.* For the testing required by paragraph (j)(1) of this section, the manufacturer shall use an off-board device to conduct the testing. The manufacturer must be able to show that the off-board device is able to verify that the vehicles tested using the device are able to perform all of the required functions in paragraph (j)(1)(iv) of this section with any other off-board device designed and built in accordance with the SAE J1978 or SAE J1939 (both as specified in paragraph (k)(1) of this section) generic scan tool specifications.

(iv) *Required testing.* The testing must verify that communication can be established properly between all emission-related on-board computers and a SAE J1978 or SAE J1939 (both as specified in paragraph (k)(1) of this section) scan tool designed to adhere strictly to the communication protocols allowed in paragraph (k)(3) of this section. The testing must also verify that all emission-related information is communicated properly between all emission-related on-board computers and a SAE J1978 or SAE J1939 (both as specified in paragraph (k)(1) of this section) scan tool in accordance with the requirements of paragraph (k)(1) of this section and the applicable ISO and SAE

specifications including specifications for physical layer, network layer, message structure, and message content. The testing must also verify that the onboard computer(s) can properly respond to a SAE J1978 or SAE J1939 (both as specified in paragraph (k)(1) of this section) scan tool request to clear emissions-related DTCs and reset the ready status in accordance with paragraph (k)(4)(ix) of this section. The testing must further verify that the following information can be properly communicated to a SAE J1978 or SAE J1939 (both as specified in paragraph (k)(1) of this section) scan tool:

(A) The current ready status from all onboard computers required to support ready status in accordance with SAE J1978 or SAE J1939-73 (both as specified in paragraph (k)(1) of this section) and paragraph (k)(4)(i) of this section in the key-on, engine-off position and while the engine is running.

(B) The MIL command status while a deactivated MIL is commanded and while an activated MIL is commanded in accordance with SAE J1979 or SAE J1939 (both as specified in paragraph (k)(1) of this section) and paragraph (k)(4)(ii) of this section in the key-on, engine-off position and while the engine is running, and in accordance with SAE J1979 or SAE J1939 (both as specified in paragraph (k)(1) of this section) and paragraphs (b)(1)(ii) of this section during the MIL functional check, if applicable, and, if applicable, (k)(4)(i)(C) of this section during the MIL ready status check while the engine is off.

(C) All data stream parameters required in paragraph (k)(4)(ii) of this section in accordance with SAE J1979 or SAE J1939 (both as specified in paragraph (k)(1) of this section) including, if applicable, the proper identification of each data stream parameter as supported in SAE J1979 (e.g., Mode/Service \$01, PID \$00).

(D) The CAL ID, CVN, and VIN as required by paragraphs (k)(4)(vi), (k)(4)(vii), and (k)(4)(viii) of this section and in accordance with SAE J1979 or SAE J1939 (both as specified in paragraph (k)(1) of this section).

(E) An emissions-related DTC (permanent, pending, MIL-on, previous-MIL-on) in accordance with SAE J1979 or SAE J1939-73 (both as specified in

paragraph (k)(1) of this section) including the correct indication of the number of stored DTCs (e.g., Mode/Service \$01, PID \$01, Data A for SAE J1979 (as specified in paragraph (k)(1) of this section)) and paragraph (k)(4)(iv) of this section.

(v) *Reporting of results.* The manufacturer must submit to the Administrator the following, based on the results of the testing required by paragraph (j)(1)(iv) of this section:

(A) If a variant meets all the requirements of paragraph (j)(1)(iv) of this section, a statement specifying that the variant passed all the tests. Upon request from the Administrator, the detailed results of any such testing may have to be submitted.

(B) If any variant does not meet the requirements paragraph (j)(1)(iv) of this section, a written report detailing the problem(s) identified and the manufacturer's proposed corrective action (if any) to remedy the problem(s). This report must be submitted within one month of testing the specific variant. The Administrator will consider the proposed remedy and, if in disagreement, will work with the manufacturer to propose an alternative remedy. Factors to be considered by the Administrator in considering the proposed remedy will include the severity of the problem(s), the ability of service technicians to access the required diagnostic information, the impact on equipment and tool manufacturers, and the amount of time prior to implementation of the proposed corrective action.

(vi) *Alternative testing protocols.* Manufacturers may request approval to use other testing protocols. To do so, the manufacturer must demonstrate that the alternative testing methods and equipment will provide an equivalent level of verification of compliance with the standardization requirements as is required by paragraph (j)(1) of this section.

(2) *Verification of monitoring requirements.* (i) Within either the first six months of the start of engine production or the first three months of the start of vehicle production, whichever is later, the manufacturer must conduct a complete evaluation of the OBD system of one or more production vehicles

(test vehicles) and submit the results of the evaluation to the Administrator.

(ii) *Selection of test vehicles.* (A) For each engine selected for monitoring system demonstration in paragraph (1) of this section, the manufacturer must evaluate one production vehicle equipped with an engine from the same engine family and rating as the demonstration engine. The vehicle selection must be approved by the Administrator.

(B) If the manufacturer is required to test more than one test vehicle, the manufacturer may test an engine in lieu of a vehicle for all but one of the required test vehicles.

(C) The requirement for submittal of data from one or more of the test vehicles may be waived if data have been submitted previously for all of the engine ratings and variants.

(iii) *Evaluation requirements.* (A) The evaluation must demonstrate the ability of the OBD system on the selected test vehicle to detect a malfunction, activate the MIL, and, where applicable, store an appropriate DTC readable by a scan tool when a malfunction is present and the monitoring conditions have been satisfied for each individual monitor required by this section. For model years 2013 and later, the evaluation must demonstrate the ability of the OBD system on the selected test vehicle to detect a malfunction, activate the MIL, and, where applicable, store an appropriate DTC readable by a SAE J1978 or SAE J1939 (both as specified in paragraph (k)(1) of this section) scan tool when a malfunction is present and the monitoring conditions have been satisfied for each individual monitor required by this section.

(B) The evaluation must verify that the malfunction of any component used to enable another OBD monitor but that does not itself result in MIL activation (e.g., fuel level sensor) will not inhibit the ability of other OBD monitors to detect malfunctions properly.

(C) The evaluation must verify that the software used to track the numerator and denominator for the purpose of determining in-use monitoring frequency increments as required by paragraph (d)(2) of this section.

(D) Malfunctions may be implanted mechanically or simulated electronically, but internal onboard computer hardware or software changes shall not be used to simulate malfunctions. For monitors that are required to indicate a malfunction before emissions exceed an emission threshold, manufacturers are not required to use malfunctioning components/systems set exactly at their malfunction criteria limits. Emission testing is not required to confirm that the malfunction is detected before the appropriate emission thresholds are exceeded.

(E) The manufacturer must submit a proposed test plan for approval prior to performing evaluation testing. The test plan must identify the method used to induce a malfunction for each monitor.

(F) If the demonstration of a specific monitor cannot be reasonably performed without causing physical damage to the test vehicle (e.g., onboard computer internal circuit malfunctions), the manufacturer may omit the specific demonstration.

(G) For evaluation of test vehicles selected in accordance with paragraph (j)(2)(ii) of this section, the manufacturer is not required to demonstrate monitors that were demonstrated prior to certification as required in paragraph (l) of this section.

(iv) The manufacturer must submit a report of the results of all testing conducted as required by paragraph (j)(2) of this section. The report must identify the method used to induce a malfunction in each monitor, the MIL activation status, and the DTC(s) stored.

(3) *Verification of in-use monitoring performance ratios.* (i) The manufacturer must collect and report in-use monitoring performance data representative of production vehicles (i.e., engine rating and chassis application combination). The manufacturer must collect and report the data to the Administrator within 12 months after the first production vehicle was first introduced into commerce.

(ii) The manufacturer must separate production vehicles into the monitoring performance groups and submit data that represents each of these groups. The groups shall be based on the following criteria:

(A) Emission control system architecture. All engines that use the same or similar emissions control system architecture (e.g., EGR with DPF and SCR; EGR with DPF and NO<sub>x</sub> adsorber; EGR with DPF-only) and associated monitoring system would be in the same emission architecture category.

(B) Vehicle application type. Within an emission architecture category, engines shall be separated into one of three vehicle application types: Engines intended primarily for line-haul chassis applications, engines intended primarily for urban delivery chassis applications, and all other engines.

(iii) The manufacturer may use an alternative grouping method to collect representative data. To do so, the manufacturer must show that the alternative groups include production vehicles using similar emission controls, OBD strategies, monitoring condition calibrations, and vehicle application driving/usage patterns such that they are expected to have similar in-use monitoring performance. The manufacturer will still be required to submit one set of data for each of the alternative groups.

(iv) For each monitoring performance group, the data must include all of the in-use performance tracking data (i.e., all numerators, denominators, the general denominator, and the ignition cycle counter), the date the data were collected, the odometer reading, the VIN, and the calibration ID. For model years 2013 and later, for each monitoring performance group, the data must include all of the in-use performance tracking data reported through SAE J1979 or SAE J1939 (both as specified in paragraph (k)(1) of this section; i.e., all numerators, denominators, the general denominator, and the ignition cycle counter), the date the data were collected, the odometer reading, the VIN, and the calibration ID.

(v) The manufacturer must submit a plan to the Administrator that details the types of production vehicles in each monitoring performance group, the number of vehicles per group to be sampled, the sampling method, the timeline to collect the data, and the reporting format. The plan must provide for effective collection of data from, at

least, 15 vehicles per monitoring performance group and provide for data that represent a broad range of temperature conditions. The plan shall not, by design, exclude or include specific vehicles in an attempt to collect data only from vehicles expected to have the highest in-use performance ratios.

(vi) The 12 month deadline for reporting may be extended to 18 months if the manufacturer can show that the delay is justified. In such a case, an interim report of progress to date must be submitted within the 12 month deadline.

(k) *Standardization requirements*—(1) *Reference materials.* The following documents are incorporated by reference, see § 86.1. Anyone may inspect copies at the U.S. EPA or at the National Archives and Records Administration (NARA). For information on the availability of this material at U.S. EPA, NARA, or the standard making bodies directly, refer to § 86.1.

(i) SAE J1930, Revised April 2002.

(ii) SAE J1939, Revised October 2007.

(iii) SAE J1939-13, Revised March 2004, for model years 2013 and later.

(iv) SAE J1939-73, Revised September 2006.

(v) SAE J1962, Revised April 2002, for model years 2013 and later.

(vi) SAE J1978, Revised April 2002.

(vii) SAE J1979, Revised May 2007.

(viii) SAE J2012, Revised April 2002.

(ix) SAE J2403, Revised August 2007.

(x) ISO 15765-4:2005(E), January 15, 2005.

(2) *Diagnostic connector.* For model years 2010 through 2012, the manufacturer defined data link connector must be accessible to a trained service technician. For model years 2013 and later, a standard data link connector conforming to SAE J1962 (as specified in paragraph (k)(1) of this section) or SAE J1939-13 (as specified in paragraph (k)(1) of this section) specifications (except as provided for in paragraph (k)(2)(iii) if this section) must be included in each vehicle.

(i) For model years 2013 and later, the connector must be located in the driver's side foot-well region of the vehicle interior in the area bound by the driver's side of the vehicle and the driver's side edge of the center console (or the

vehicle centerline if the vehicle does not have a center console) and at a location no higher than the bottom of the steering wheel when in the lowest adjustable position. The connector shall not be located on or in the center console (i.e., neither on the horizontal faces near the floor-mounted gear selector, parking brake lever, or cupholders nor on the vertical faces near the car stereo, climate system, or navigation system controls). The location of the connector shall be capable of being easily identified and accessed (e.g., to connect an off-board tool). For vehicles equipped with a driver's side door, the connector must be identified and accessed easily by someone standing (or "crouched") on the ground outside the driver's side of the vehicle with the driver's side door open. The Administrator may approve an alternative location upon request from the manufacturer. In all cases, the installation position of the connector must be both identified and accessed easily by someone standing outside the vehicle and protected from accidental damage during normal vehicle use.

(ii) For model years 2013 and later, if the connector is covered, the cover must be removable by hand without the use of any tools and be labeled "OBD" to aid technicians in identifying the location of the connector. Access to the diagnostic connector shall not require opening or the removal of any storage accessory (e.g., ashtray, coinbox). The label must clearly identify that the connector is located behind the cover and is consistent with language and/or symbols commonly used in the automobile and/or heavy truck industry.

(iii) For model years 2013 and later, if the ISO 15765-4:2005(E) (as specified in paragraph (k)(1) of this section) communication protocol is used for the required OBD standardized functions, the connector must meet the "Type A" specifications of SAE J1962 (as specified in paragraph (k)(1) of this section). Any pins in the connector that provide electrical power must be properly fused to protect the integrity and usefulness of the connector for diagnostic purposes and shall not exceed 20.0 Volts DC regardless of the nominal vehicle

system or battery voltage (e.g., 12V, 24V, 42V).

(iv) For model years 2013 and later, if the SAE J1939 (as specified in paragraph (k)(1) of this section) protocol is used for the required OBD standardized functions, the connector must meet the specifications of SAE J1939-13 (as specified in paragraph (k)(1) of this section). Any pins in the connector that provide electrical power must be properly fused to protect the integrity and usefulness of the connector for diagnostic purposes.

(v) For model years 2013 and later, the manufacturer may equip engines/vehicles with additional diagnostic connectors for manufacturer-specific purposes (i.e., purposes other than the required OBD functions). However, if the additional connector conforms to the "Type A" specifications of SAE J1962 (as specified in paragraph (k)(1) of this section) or the specifications of SAE J1939-13 (as specified in paragraph (k)(1) of this section) and is located in the vehicle interior near the required connector as described in this paragraph (k)(2), the connector(s) must be labeled clearly to identify which connector is used to access the standardized OBD information required by paragraph (k) of this section.

(3) *Communications to a scan tool.* For model years 2013 and later, all OBD control modules (e.g., engine, auxiliary emission control module) on a single vehicle must use the same protocol for communication of required emission-related messages from on-board to off-board network communications to a scan tool meeting SAE J1978 (as specified in paragraph (k)(1) of this section) specifications or designed to communicate with an SAE J1939 (as specified in paragraph (k)(1) of this section) network. Engine manufacturers shall not alter normal operation of the engine emission control system due to the presence of off-board test equipment accessing information required by this paragraph (k). The OBD system must use one of the following standardized protocols:

(i) ISO 15765-4:2005(E) (as specified in paragraph (k)(1) of this section). All required emission-related messages using this protocol must use a 500 kbps baud rate.

(ii) SAE J1939 (as specified in paragraph (k)(1) of this section). This protocol may only be used on vehicles with diesel engines.

(4) *Required emission related functions.* The following functions must be implemented and must be accessible by, at a minimum, a manufacturer scan tool. For model years 2013 and later, the following standardized functions must be implemented in accordance with the specifications in SAE J1979 (as specified in paragraph (k)(1) of this section) or SAE J1939 (as specified in paragraph (k)(1) of this section) to allow for access to the required information by a scan tool meeting SAE J1978 (as specified in paragraph (k)(1) of this section) specifications or designed to communicate with an SAE J1939 (as specified in paragraph (k)(1) of this section) network:

(i) *Ready status.* The OBD system must indicate, in accordance with SAE J1979 or SAE J1939-73 (both as specified in paragraph (k)(1) of this section) specifications for model years 2013 and later, "complete" or "not complete" for each of the installed monitored components and systems identified in paragraphs (g), (h) with the exception of (h)(4), and (i)(3) of this section. All components or systems identified in paragraphs (h)(1), (h)(2), or (i)(3) of this section that are monitored continuously must always indicate "complete." Components or systems that are not subject to being monitored continuously must immediately indicate "complete" upon the respective monitor(s) being executed fully and determining that the component or system is not malfunctioning. A component or system must also indicate "complete" if, after the requisite number of decisions necessary for determining MIL status has been executed fully, the monitor indicates a malfunction of the component or system. The status for each of the monitored components or systems must indicate "not complete" whenever diagnostic memory has been cleared or erased by a means other than that allowed in paragraph (b) of this section. Normal vehicle shut down (i.e., key-off/engine-off) shall not cause the status to indicate "not complete."

(A) The manufacturer may request that the ready status for a monitor be



set to indicate “complete” without the monitor having completed if monitoring is disabled for a multiple number of drive cycles due to the continued presence of extreme operating conditions (e.g., cold ambient temperatures, high altitudes). Any such request must specify the conditions for monitoring system disablement and the number of drive cycles that would pass without monitor completion before ready status would be indicated as “complete.”

(B) For the evaporative system monitor, the ready status must be set in accordance with this paragraph (k)(4)(i) when both the functional check of the purge valve and, if applicable, the leak detection monitor of the hole size specified in paragraph (h)(7)(ii)(B) of this section indicate that they are complete.

(C) If the manufacturer elects to indicate ready status through the MIL in the key-on/engine-off position as provided for in paragraph (b)(1)(iii) of this section, the ready status must be indicated in the following manner: If the ready status for all monitored components or systems is “complete,” the MIL shall remain continuously activated in the key-on/engine-off position for at least 10–20 seconds. If the ready status for one or more of the monitored components or systems is “not complete,” after at least 5 seconds of operation in the key-on/engine-off position with the MIL activated continuously, the MIL shall blink once per second for 5–10 seconds. The data stream value for MIL status as required in paragraph (k)(4)(ii) of this section must indicate “commanded off” during this sequence unless the MIL has also been “commanded on” for a detected malfunction.

(ii) *Data stream.* For model years 2010 through 2012, the following signals must be made available on demand through the data link connector. For model years 2013 and later, the following signals must be made available on demand through the standardized data link connector in accordance with SAE J1979 or SAE J1939 (both as specified in paragraph (k)(1) of this section) specifications. The actual signal value must always be used instead of a limp home value. Data link signals may report an error state or other predefined

status indicator if they are defined for those signals in the SAE J1979 or SAE J1939 (both as specified in paragraph (k)(1) of this section) specifications.

(A) *For gasoline engines.* (1) Calculated load value, engine coolant temperature, engine speed, vehicle speed, and time elapsed since engine start.

(2) Absolute load, fuel level (if used to enable or disable any other monitors), barometric pressure (directly measured or estimated), engine control module system voltage, and commanded equivalence ratio.

(3) Number of stored MIL-on DTCs, catalyst temperature (if directly measured or estimated for purposes of enabling the catalyst monitor(s)), monitor status (i.e., disabled for the rest of this drive cycle, complete this drive cycle, or not complete this drive cycle) since last engine shut-off for each monitor used for ready status, distance traveled (or engine run time for engines not using vehicle speed information) while MIL activated, distance traveled (or engine run time for engines not using vehicle speed information) since DTC memory last erased, and number of warm-up cycles since DTC memory last erased, OBD requirements to which the engine is certified (e.g., California OBD, EPA OBD, European OBD, non-OBD) and MIL status (i.e., commanded-on or commanded-off).

(B) *For diesel engines.* (1) Calculated load (engine torque as a percentage of maximum torque available at the current engine speed), driver’s demand engine torque (as a percentage of maximum engine torque), actual engine torque (as a percentage of maximum engine torque), reference engine maximum torque, reference maximum engine torque as a function of engine speed (suspect parameter numbers (SPN) 539 through 543 defined by SAE J1939 (as specified in paragraph (k)(1) of this section) within parameter group number (PGN) 65251 for engine configuration), engine coolant temperature, engine oil temperature (if used for emission control or any OBD monitors), engine speed, and time elapsed since engine start.

(2) Fuel level (if used to enable or disable any other monitors), vehicle speed (if used for emission control or any OBD monitors), barometric pressure

(directly measured or estimated), and engine control module system voltage.

(3) Number of stored MIL-on DTCs, monitor status (i.e., disabled for the rest of this drive cycle, complete this drive cycle, or not complete this drive cycle) since last engine shut-off for each monitor used for ready status, distance traveled (or engine run time for engines not using vehicle speed information) while MIL activated, distance traveled (or engine run time for engines not using vehicle speed information) since DTC memory last erased, number of warm-up cycles since DTC memory last erased, OBD requirements to which the engine is certified (e.g., California OBD, EPA OBD, European OBD, non-OBD), and MIL status (i.e., commanded-on or commanded-off).

(4) NO<sub>x</sub> NTE control area status (i.e., inside control area, outside control area, inside manufacturer-specific NO<sub>x</sub> NTE carve-out area, or deficiency active area) and PM NTE control area status (i.e., inside control area, outside control area, inside manufacturer-specific PM NTE carve-out area, or deficiency active area).

(5) For purposes of the calculated load and torque parameters in paragraph (k)(4)(ii)(B)(1) of this section, manufacturers must report the most accurate values that are calculated within the applicable electronic control unit (e.g., the engine control module). Most accurate, in this context, must be of sufficient accuracy, resolution, and filtering to be used for the purposes of in-use emission testing with the engine still in a vehicle (e.g., using portable emission measurement equipment).

(C) *For all engines so equipped.*

(1) Absolute throttle position, relative throttle position, fuel control system status (e.g., open loop, closed loop), fuel trim, fuel pressure, ignition timing advance, fuel injection timing, intake air/manifold temperature, engine intercooler temperature, manifold absolute pressure, air flow rate from mass air flow sensor, secondary air status (upstream, downstream, or atmosphere), ambient air temperature, commanded purge valve duty cycle/position, commanded EGR valve duty cycle/position, actual EGR valve duty cycle/position, EGR error between ac-

tual and commanded, PTO status (active or not active), redundant absolute throttle position (for electronic throttle or other systems that utilize two or more sensors), absolute pedal position, redundant absolute pedal position, commanded throttle motor position, fuel rate, boost pressure, commanded/target boost pressure, turbo inlet air temperature, fuel rail pressure, commanded fuel rail pressure, DPF inlet pressure, DPF inlet temperature, DPF outlet pressure, DPF outlet temperature, DPF delta pressure, exhaust pressure sensor output, exhaust gas temperature sensor output, injection control pressure, commanded injection control pressure, turbocharger/turbine speed, variable geometry turbo position, commanded variable geometry turbo position, turbocharger compressor inlet temperature, turbocharger compressor inlet pressure, turbocharger turbine inlet temperature, turbocharger turbine outlet temperature, waste gate valve position, and glow plug lamp status.

(2) Oxygen sensor output, air/fuel ratio sensor output, NO<sub>x</sub> sensor output, and evaporative system vapor pressure.

(iii) *Freeze frame.* (A) For model years 2010 through 2012, "Freeze frame" information required to be stored pursuant to paragraphs (b)(2)(iv), (h)(1)(iv)(D), and (h)(2)(vi) of this section must be made available on demand through the data link connector. For model years 2013 and later, "Freeze frame" information required to be stored pursuant to paragraphs (b)(2)(iv), (h)(1)(iv)(D), and (h)(2)(vi) of this section must be made available on demand through the standardized data link connector in accordance with SAE J1979 or SAE J1939-73 (both as specified in paragraph (k)(1) of this section) specifications.

(B) "Freeze frame" conditions must include the DTC that caused the data to be stored along with all of the signals required in paragraphs (k)(4)(ii)(A)(1) and (k)(4)(ii)(B)(1) of this section. Freeze frame conditions must also include all of the signals required on the engine in paragraphs (k)(4)(ii)(A)(2) and (k)(4)(ii)(B)(2) of this section, and paragraph (k)(4)(ii)(C)(1) of

this section that are used for diagnostic or control purposes in the specific monitor or emission-critical powertrain control unit that stored the DTC.

(C) Only one frame of data is required to be recorded. For model years 2010 through 2012, the manufacturer may choose to store additional frames provided that at least the required frame can be read by, at a minimum, a manufacturer scan tool. For model years 2013 and later, the manufacturer may choose to store additional frames provided that at least the required frame can be read by a scan tool meeting SAE J1978 (as specified in paragraph (k)(1) of this section) specifications or designed to communicate with an SAE J1939 (as specified in paragraph (k)(1) of this section) network.

(iv) *Diagnostic trouble codes.* (A) For model years 2010 through 2012, For all monitored components and systems, any stored pending, MIL-on, and previous-MIL-on DTCs must be made available through the diagnostic connector. For model years 2013 and later, all monitored components and systems, any stored pending, MIL-on, and previous-MIL-on DTCs must be made available through the diagnostic connector in a standardized format in accordance with SAE J1939 (as specified in paragraph (k)(1) of this section) or ISO 15765-4:2005(E) (as specified in paragraph (k)(1) of this section) specifications; standardized DTCs conforming to the applicable standardized specifications must be employed.

(B) The stored DTC must, to the extent possible, pinpoint the probable cause of the malfunction or potential malfunction. To the extent feasible, the manufacturer must use separate DTCs for every monitor where the monitor and repair procedure or probable cause of the malfunction is different. In general, rationality and functional checks must use different DTCs than the respective circuit integrity checks. Additionally, to the extent possible, input component circuit integrity checks must use different DTCs for distinct malfunctions (e.g., out-of-range low, out-of-range high, open circuit).

(C) The manufacturer must use appropriate standard-defined DTCs when-

ever possible. With Administrator approval, the manufacturer may use manufacturer-defined DTCs in accordance with the applicable standard's specifications. To do so, the manufacturer must be able to show a lack of available standard-defined DTCs, uniqueness of the monitor or monitored component, expected future usage of the monitor or component, and estimated usefulness in providing additional diagnostic and repair information to service technicians. Manufacturer-defined DTCs must be used in a consistent manner (i.e., the same DTC shall not be used to represent two different failure modes) across a manufacturer's entire product line.

(D) For model years 2010 through 2012, a pending or MIL-on DTC (as required in paragraphs (g) through (i) of this section) must be stored and available to, at a minimum, a manufacturer scan tool within 10 seconds after a monitor has determined that a malfunction or potential malfunction has occurred. A permanent DTC must be stored and available to, at a minimum, a manufacturer scan tool no later than the end of an ignition cycle in which the corresponding MIL-on DTC that caused MIL activation has been stored. For model years 2013 and later, a pending or MIL-on DTC (as required in paragraphs (g) through (i) of this section) must be stored and available to an SAE J1978 (as specified in paragraph (k)(1) of this section) or SAE J1939 (as specified in paragraph (k)(1) of this section) scan tool within 10 seconds after a monitor has determined that a malfunction or potential malfunction has occurred. A permanent DTC must be stored and available to an SAE J1978 (as specified in paragraph (k)(1) of this section) or SAE J1939 (as specified in paragraph (k)(1) of this section) scan tool no later than the end of an ignition cycle in which the corresponding MIL-on DTC that caused MIL activation has been stored.

(E) For model years 2010 through 2012, pending DTCs for all components and systems (including those monitored continuously and non-continuously) must be made available through the diagnostic connector. For model years 2013 and later, pending DTCs for all components and systems (including

those monitored continuously and non-continuously) must be made available through the diagnostic connector in accordance with the applicable standard's specifications. For all model years, a manufacturer using alternative statistical protocols for MIL activation as allowed in paragraph (b)(2)(iii) of this section must submit the details of their protocol for setting pending DTCs. The protocol must be, overall, equivalent to the requirements of this paragraph (k)(4)(iv)(E) and provide service technicians with a quick and accurate indication of a potential malfunction.

(F) For model years 2010 through 2012, permanent DTC for all components and systems must be made available through the diagnostic connector in a format that distinguishes permanent DTCs from pending DTCs, MIL-on DTCs, and previous-MIL-on DTCs. A MIL-on DTC must be stored as a permanent DTC no later than the end of the ignition cycle and subsequently at all times that the MIL-on DTC is commanding the MIL on. For model years 2013 and later, permanent DTC for all components and systems must be made available through the diagnostic connector in a standardized format that distinguishes permanent DTCs from pending DTCs, MIL-on DTCs, and previous-MIL-on DTCs. A MIL-on DTC must be stored as a permanent DTC no later than the end of the ignition cycle and subsequently at all times that the MIL-on DTC is commanding the MIL on. For all model years, permanent DTCs must be stored in non-volatile random access memory (NVRAM) and shall not be erasable by any scan tool command or by disconnecting power to the on-board computer. Permanent DTCs must be erasable if the engine control module is reprogrammed and the ready status described in paragraph (k)(4)(i) of this section for all monitored components and systems are set to "not complete." The OBD system must have the ability to store a minimum of four current MIL-on DTCs as permanent DTCs in NVRAM. If the number of MIL-on DTCs currently commanding activation of the MIL exceeds the maximum number of permanent DTCs that can be stored, the OBD system must store the earliest detected

MIL-on DTC as permanent DTC. If additional MIL-on DTCs are stored when the maximum number of permanent DTCs is already stored in NVRAM, the OBD system shall not replace any existing permanent DTC with the additional MIL-on DTCs.

(v) *Test results.* (A) For model years 2010 through 2012 and except as provided for in paragraph (k)(4)(v)(G) of this section, for all monitored components and systems identified in paragraphs (g) and (h) of this section, results of the most recent monitoring of the components and systems and the test limits established for monitoring the respective components and systems must be stored and available through the data link. For model years 2013 and later and except as provided for in paragraph (k)(4)(v)(G) of this section, for all monitored components and systems identified in paragraphs (g) and (h) of this section, results of the most recent monitoring of the components and systems and the test limits established for monitoring the respective components and systems must be stored and available through the data link in accordance with the standardized format specified in SAE J1979 (as specified in paragraph (k)(1) of this section) for engines using the ISO 15765-4:2005(E) (as specified in paragraph (k)(1) of this section) protocol or SAE J1939 (as specified in paragraph (k)(1) of this section).

(B) The test results must be reported such that properly functioning components and systems (e.g., "passing" systems) do not store test values outside of the established test limits. Test limits must include both minimum and maximum acceptable values and must be defined so that a test result equal to either test limit is a "passing" value, not a "failing" value.

(C) For model years 2013 and later, the test results must be standardized such that the name of the monitored component (e.g., catalyst bank 1) can be identified by a generic scan tool and the test results and limits can be scaled and reported by a generic scan tool with the appropriate engineering units.

(D) The test results must be stored until updated by a more recent valid test result or the DTC memory of the

OBD system computer is cleared. Upon DTC memory being cleared, test results reported for monitors that have not yet completed with valid test results since the last time the fault memory was cleared must report values of zero for the test result and test limits.

(E) All test results and test limits must always be reported and the test results must be stored until updated by a more recent valid test result or the DTC memory of the OBD system computer is cleared.

(F) The OBD system must store and report unique test results for each separate monitor.

(G) The requirements of this paragraph (k)(4)(v) do not apply to continuous fuel system monitoring, cold start emission reduction strategy monitoring, and continuous circuit monitoring.

(vi) *Software calibration identification (CAL ID)*. On all engines, a single software calibration identification number (CAL ID) for each monitor or emission critical control unit(s) must be made available through, for model years 2010 through 2012, the data link connector or, for model years 2013 and later, the standardized data link connector in accordance with the SAE J1979 or SAE J1939 (both as specified in paragraph (k)(1) of this section) specifications. A unique CAL ID must be used for every emission-related calibration and/or software set having at least one bit of different data from any other emission-related calibration and/or software set. Control units coded with multiple emission or diagnostic calibrations and/or software sets must indicate a unique CAL ID for each variant in a manner that enables an off-board device to determine which variant is being used by the engine. Control units that use a strategy that will result in MIL activation if the incorrect variant is used (e.g., control units that contain variants for manual and automatic transmissions but will activate the MIL if the selected variant does not match the type of transmission mated to the engine) are not required to use unique CAL IDs. Manufacturers may request Administrator approval to respond with more than one CAL ID per diagnostic or emission critical control

unit. Administrator approval of the request shall be based on the method used by the manufacturer to ensure each control unit will respond to a scan tool with the CAL IDs in order of highest to lowest priority with regards to areas of the software most critical to emission and OBD system performance.

(vii) *Software calibration verification number (CVN)*. (A) All engines must use an algorithm to calculate a single calibration verification number (CVN) that verifies the on-board computer software integrity for each monitor or emission critical control unit that is electronically reprogrammable. The CVN must be made available through, for model years 2010 through 2012, the data link connector or, for model years 2013 and later, the standardized data link connector in accordance with the SAE J1979 or SAE J1939 (both as specified in paragraph (k)(1) of this section) specifications. The CVN must indicate whether the emission-related software and/or calibration data are valid and applicable for the given vehicle and CAL ID. For systems having more than one CAL ID as allowed under paragraph (k)(4)(vi) of this section, one CVN must be made available for each CAL ID and must be output to a scan tool in the same order as the corresponding CAL IDs. For 2010 through 2012, manufacturers may use a default value for the CVN if their emissions critical powertrain control modules are not programmable in the field. For all years, manufacturers may use a default value for the CVN if their emissions critical powertrain control modules are one-time programmable or masked read-only memory. Any default CVN shall be 00000000 for systems designed in accordance with the SAE J1979 (as specified in paragraph (k)(1) of this section) specifications, and FFFFFFFFh for systems designed in accordance with the SAE J1939 (as specified in paragraph (k)(1) of this section) specifications.

(B) The CVN algorithm used to calculate the CVN must be of sufficient complexity that the same CVN is difficult to achieve with modified calibration values.

(C) The CVN must be calculated at least once per ignition cycle and stored until the CVN is subsequently updated.

Except for immediately after a reprogramming event or a non-volatile memory clear or for the first 30 seconds of engine operation after a volatile memory clear or battery disconnect, the stored value must be made available through, for model years 2010 through 2012, the data link connector to, at a minimum, a manufacturer scan tool or, for model years 2013 and later, the data link connector to a generic scan tool in accordance with SAE J1979 or SAE J1939 (both as specified in paragraph (k)(1) of this section) specifications. For model years 2010 through 2012, the stored CVN value shall not be erased when DTC memory is erased or during normal vehicle shut down (i.e., key-off/engine-off). For model years 2013 and later, the stored CVN value shall not be erased when DTC memory is erased by a generic scan tool in accordance with SAE J1979 or SAE J1939 (both as specified in paragraph (k)(1) of this section) specifications or during normal vehicle shut down (i.e., key-off/engine-off).

(D) For model years 2013 and later, the CVN and CAL ID combination information must be available for all engines/vehicles in a standardized electronic format that allows for off-board verification that the CVN is valid and appropriate for a specific vehicle and CAL ID.

(viii) *Vehicle identification number (VIN)*. (A) For model years 2010 through 2012, all vehicles must have the vehicle identification number (VIN) available through the data link connector to, at a minimum, a manufacturer scan tool. Only one electronic control unit per vehicle may report the VIN to a scan tool. For model years 2013 and later, all vehicles must have the vehicle identification number (VIN) available in a standardized format through the standardized data link connector in accordance with SAE J1979 or SAE J1939 (both as specified in paragraph (k)(1) of this section) specifications. Only one electronic control unit per vehicle may report the VIN to an SAE J1978 or SAE J1939 (both as specified in paragraph (k)(1) of this section) scan tool.

(B) If the VIN is reprogrammable, all emission-related diagnostic information identified in paragraph (k)(4)(ix)(A) of this section must be

erased in conjunction with reprogramming of the VIN.

(ix) *Erasure of diagnostic information*. (A) For purposes of this paragraph (k)(4)(ix), "emission-related diagnostic information" includes all of the following: ready status as required by paragraph (k)(4)(i) of this section; data stream information as required by paragraph (k)(4)(ii) of this section including the number of stored MIL-on DTCs, distance traveled while MIL activated, number of warm-up cycles since DTC memory last erased, and distance traveled since DTC memory last erased; freeze frame information as required by paragraph (k)(4)(iii) of this section; pending, MIL-on, and previous-MIL-on DTCs as required by paragraph (k)(4)(iv) of this section; and, test results as required by paragraph (k)(4)(v) of this section.

(B) For all engines, the emission-related diagnostic information must be erased if commanded by any scan tool and may be erased if the power to the on-board computer is disconnected. If any of the emission-related diagnostic information is commanded to be erased by any scan tool, all emission-related diagnostic information must be erased from all diagnostic or emission critical control units. The OBD system shall not allow a scan tool to erase a subset of the emission-related diagnostic information (e.g., the OBD system shall not allow a scan tool to erase only one of three stored DTCs or only information from one control unit without erasing information from the other control unit(s)).

(5) *In-use performance ratio tracking requirements*. (i) For each monitor required in paragraphs (g) through (i) of this section to separately report an in-use performance ratio, manufacturers must implement software algorithms to, for model years 2010 through 2012, report a numerator and denominator or, for model years 2013 and later, report a numerator and denominator in the standardized format specified in this paragraph (k)(5) in accordance with the SAE J1979 or SAE J1939 (both as specified in paragraph (k)(1) of this section) specifications.

(ii) For the numerator, denominator, general denominator, and ignition cycle counters required by paragraph

(e) of this section, the following numerical value specifications apply:

(A) Each number shall have a minimum value of zero and a maximum value of 65,535 with a resolution of one.

(B) Each number shall be reset to zero only when a non-volatile random access memory (NVRAM) reset occurs (e.g., reprogramming event) or, if the numbers are stored in keep-alive memory (KAM), when KAM is lost due to an interruption in electrical power to the control unit (e.g., battery disconnect). Numbers shall not be reset to zero under any other circumstances including when a scan tool command to clear DTCs or reset KAM is received.

(C) To avoid overflow problems, if either the numerator or denominator for a specific component reaches the maximum value of 65,535  $\pm 2$ , both numbers shall be divided by two before either is incremented again.

(D) To avoid overflow problems, if the ignition cycle counter reaches the maximum value of 65,535  $\pm 2$ , the ignition cycle counter shall rollover and increment to zero on the next ignition cycle.

(E) To avoid overflow problems, if the general denominator reaches the maximum value of 65,535  $\pm 2$ , the general denominator shall rollover and increment to zero on the next drive cycle that meets the general denominator definition.

(F) If a vehicle is not equipped with a component (e.g., oxygen sensor bank 2, secondary air system), the corresponding numerator and denominator for that specific component shall always be reported as zero.

(iii) For the ratio required by paragraph (e) of this section, the following numerical value specifications apply:

(A) The ratio shall have a minimum value of zero and a maximum value of 7.99527 with a resolution of 0.000122.

(B) The ratio for a specific component shall be considered to be zero whenever the corresponding numerator is equal to zero and the corresponding denominator is not zero.

(C) The ratio for a specific component shall be considered to be the maximum value of 7.99527 if the corresponding denominator is zero or if the actual value of the numerator di-

vided by the denominator exceeds the maximum value of 7.99527.

(6) *Engine run time tracking requirements.* (i) For all gasoline and diesel engines, the manufacturer must implement software algorithms to, for model years 2010 through 2012, track and report individually or, for model years 2013 and later, track and report individually in a standardized format the amount of time the engine has been operated in the following conditions:

(A) Total engine run time.

(B) Total idle run time (with "idle" defined as accelerator pedal released by the driver, engine speed less than or equal to 200 rpm above normal warmed-up idle (as determined in the drive position for vehicles equipped with an automatic transmission) or vehicle speed less than or equal to one mile per hour, and power take-off not active).

(C) Total run time with power take off active.

(ii) For each counter specified in paragraph (k)(6)(i) of this section, the following numerical value specifications apply:

(A) Each number shall be a four-byte value with a minimum value of zero, a resolution of one second per bit, and an accuracy of  $\pm$  ten seconds per drive cycle.

(B) Each number shall be reset to zero only when a non-volatile memory reset occurs (e.g., reprogramming event). Numbers shall not be reset to zero under any other circumstances including when a scan tool (generic or enhanced) command to clear fault codes or reset KAM is received.

(C) To avoid overflow problems, if any of the individual counters reach the maximum value, all counters shall be divided by two before any are incremented again.

(D) For model years 2010 through 2012, the counters shall be made available to, at a minimum, a manufacturer scan tool and may be rescaled when transmitted from a resolution of one second per bit to no more than three minutes per bit. For model years 2013 and later, the counters shall be made available to a generic scan tool in accordance with the SAE J1979 or SAE J1939 (both as specified in paragraph (k)(1) of this section) specifications and may be rescaled when transmitted, if

required by the SAE specifications, from a resolution of one second per bit to no more than three minutes per bit.

(7) For 2019 and subsequent model year alternative-fueled engines derived from a diesel-cycle engine, a manufacturer may meet the standardization requirements of paragraph (k) of this section that are applicable to diesel engines rather than the requirements applicable to gasoline engines.

(l) *Monitoring system demonstration requirements for certification*—(1) *General*.

(i) The manufacturer must submit emissions test data from one or more durability demonstration test engines (test engines).

(ii) The Administrator may approve other demonstration protocols if the manufacturer can provide comparable assurance that the malfunction criteria are chosen based on meeting the malfunction criteria requirements and that the timeliness of malfunction detection is within the constraints of the applicable monitoring requirements.

(iii) For flexible fuel engines capable of operating on more than one fuel or fuel combinations, the manufacturer must submit a plan for providing emission test data. The plan must demonstrate that testing will represent properly the expected in-use fuel or fuel combinations.

(2) *Selection of test engines*. (i) Prior to submitting any applications for certification for a model year, the manufacturer must notify the Administrator regarding the planned engine families and engine ratings within each family for that model year. The Administrator will select the engine family(ies) and the specific engine rating within the engine family(ies) that the manufacturer shall use as demonstration test engines. The selection of test vehicles for production evaluation testing as specified in paragraph (j)(2) of this section may take place during this selection process.

(ii) *For model years 2010 through 2012*. The manufacturer must provide emissions test data from the OBD parent rating as defined in paragraph (o)(1) of this section.

(iii) *For model years 2013 and later*. (A) A manufacturer certifying one to five engine families in a given model year must provide emissions test data for a

single test engine from one engine rating. A manufacturer certifying six to ten engine families in a given model year must provide emissions test data for a single test engine from two different engine ratings. A manufacturer certifying eleven or more engine families in a given model year must provide emissions test data for a single test engine from three different engine ratings. A manufacturer may forego submittal of test data for one or more of these test engines if data have been submitted previously for all of the engine ratings and/or if all requirements for certification carry-over from one model year to the next are satisfied.

(B) For a given model year, a manufacturer may elect to provide emissions data for test engines from more engine ratings than required by paragraph (1)(2)(iii)(A) of this section. For each additional engine rating tested in that given model year, the number of engine ratings required for testing in one future model year will be reduced by one.

(iv) For the test engine, the manufacturer must use an engine (excluding aftertreatment devices) aged for a minimum of 125 hours fitted with exhaust aftertreatment emission controls aged to be representative of useful life aging. In the event that an accelerated aging procedure is used, the manufacturer is required to submit a description of the accelerated aging process and/or supporting data or use the accelerated aging procedure used for emission certification deterioration factor generation. The process and/or data must demonstrate that deterioration of the exhaust aftertreatment emission controls is stabilized sufficiently such that it represents emission control performance at the end of the useful life.

(3) *Required testing*. Except as otherwise described in this paragraph (1)(3), the manufacturer must perform single malfunction testing based on the applicable test with the components/systems set at their malfunction criteria limits as determined by the manufacturer for meeting the emissions thresholds required in paragraphs (g), (h), and (i) of this section.

(i) *Required testing for diesel-fueled/compression ignition engines*—(A) *Fuel*



*system.* The manufacturer must perform a separate test for each malfunction limit established by the manufacturer for the fuel system parameters (e.g., fuel pressure, injection timing) specified in paragraphs (g)(1)(ii)(A) through (g)(1)(ii)(D) of this section, if applicable, of this section. When performing a test for a specific parameter, the fuel system must be operating at the malfunction criteria limit for the applicable parameter only. All other parameters must be operating with normal characteristics. In conducting the fuel system demonstration tests, the manufacturer may use computer modifications to cause the fuel system to operate at the malfunction limit if the manufacturer can demonstrate that the computer modifications produce test results equivalent to an induced hardware malfunction.

(B) *Engine misfire.* For model years 2013 and later, the manufacturer must perform a test at the malfunction limit established by the manufacturer for the monitoring required by paragraph (g)(2)(ii)(B) of this section.

(C) *EGR system.* The manufacturer must perform a separate test for each malfunction limit established by the manufacturer for the EGR system parameters (e.g., low flow, high flow, slow response) specified in paragraphs (g)(3)(ii)(A) through (g)(3)(ii)(C) and in (g)(3)(ii)(E) of this section. In conducting the EGR system slow response demonstration tests, the manufacturer may use computer modifications to cause the EGR system to operate at the malfunction limit if the manufacturer can demonstrate that the computer modifications produce test results equivalent to an induced hardware malfunction.

(D) *Turbo boost control system.* The manufacturer must perform a separate test for each malfunction limit established by the manufacturer for the turbo boost control system parameters (e.g., underboost, overboost, response) specified in paragraphs (g)(4)(ii)(A) through (g)(4)(ii)(C) and in (g)(4)(ii)(E) of this section.

(E) *NMHC catalyst.* The manufacturer must perform a separate test for each monitored NMHC catalyst(s). The catalyst(s) being evaluated must be dete-

riorated to the applicable malfunction limit established by the manufacturer for the monitoring required by paragraph (g)(5)(ii)(A) of this section and using methods established by the manufacturer in accordance with paragraph (1)(7) of this section. For each monitored NMHC catalyst(s), the manufacturer must also demonstrate that the OBD system will detect a catalyst malfunction with the catalyst at its maximum level of deterioration (i.e., the substrate(s) completely removed from the catalyst container or “empty” can). Emissions data are not required for the empty can demonstration.

(F) *NO<sub>x</sub> catalyst.* The manufacturer must perform a separate test for each monitored NO<sub>x</sub> catalyst(s) (e.g., SCR catalyst). The catalyst(s) being evaluated must be deteriorated to the applicable malfunction criteria established by the manufacturer for the monitoring required by paragraphs (g)(6)(ii)(A) and (g)(6)(ii)(B) of this section and using methods established by the manufacturer in accordance with paragraph (1)(7) of this section. For each monitored NO<sub>x</sub> catalyst(s), the manufacturer must also demonstrate that the OBD system will detect a catalyst malfunction with the catalyst at its maximum level of deterioration (i.e., the substrate(s) completely removed from the catalyst container or “empty” can). Emissions data are not required for the empty can demonstration.

(G) *NO<sub>x</sub> adsorber.* The manufacturer must perform a test using a NO<sub>x</sub> adsorber(s) deteriorated to the applicable malfunction limit established by the manufacturer for the monitoring required by paragraph (g)(7)(ii)(A) of this section. The manufacturer must also demonstrate that the OBD system will detect a NO<sub>x</sub> adsorber malfunction with the NO<sub>x</sub> adsorber at its maximum level of deterioration (i.e., the substrate(s) completely removed from the container or “empty” can). Emissions data are not required for the empty can demonstration.

(H) *Diesel particulate filter.* The manufacturer must perform a separate test using a DPF deteriorated to the applicable malfunction limits established by the manufacturer for the monitoring required by paragraph (g)(8)(ii)(A) and

(g)(8)(ii)(B) of this section. For systems using the optional DPF monitoring provision of paragraph (g)(8)(ii)(A) of this section, the manufacturer must perform a separate test using a DPF modified in a manner approved by the Administrator (e.g., drilling of wallflow channel end plugs, drilling of through holes, etc.) and testing at each of the nine test points specified in paragraph (g)(8)(ii)(A) of this section. The manufacturer must also demonstrate that the OBD system will detect a DPF malfunction with the DPF at its maximum level of deterioration (i.e., the filter(s) completely removed from the filter container or “empty” can). Emissions data are not required for the empty can demonstration.

(I) *Exhaust gas sensor.* The manufacturer must perform a separate test for each malfunction limit established by the manufacturer for the monitoring required in paragraphs (g)(9)(ii)(A), (g)(9)(iii)(A), and (g)(9)(iv)(A) of this section. When performing a test, all exhaust gas sensors used for the same purpose (e.g., for the same feedback control loop, for the same control feature on parallel exhaust banks) must be operating at the malfunction criteria limit for the applicable parameter only. All other exhaust gas sensor parameters must be operating with normal characteristics.

(J) *VVT system.* The manufacturer must perform a separate test for each malfunction limit established by the manufacturer for the monitoring required in paragraphs (g)(10)(ii)(A) and (g)(10)(ii)(B) of this section. In conducting the VVT system demonstration tests, the manufacturer may use computer modifications to cause the VVT system to operate at the malfunction limit if the manufacturer can demonstrate that the computer modifications produce test results equivalent to an induced hardware malfunction.

(K) For each of the testing requirements of this paragraph (1)(3)(i) of this section, if the manufacturer has established that only a functional check is required because no failure or deterioration of the specific tested system could result in an engine's emissions exceeding the applicable emissions thresholds, the manufacturer is not re-

quired to perform a demonstration test; however, the manufacturer is required to provide the data and/or engineering analysis used to determine that only a functional test of the system(s) is required.

(ii) *Required testing for gasoline-fueled/spark-ignition engines—(A) Fuel system.* For engines with adaptive feedback based on the primary fuel control sensor(s), the manufacturer must perform a test with the adaptive feedback based on the primary fuel control sensor(s) at the rich limit(s) and a test at the lean limit(s) established by the manufacturer as required by paragraph (h)(1)(ii)(A) of this section to detect a malfunction before emissions exceed applicable emissions thresholds. For engines with feedback based on a secondary fuel control sensor(s) and subject to the malfunction criteria in paragraph (h)(1)(ii)(A) of this section, the manufacturer must perform a test with the feedback based on the secondary fuel control sensor(s) at the rich limit(s) and a test at the lean limit(s) established by the manufacturer as required by paragraph (h)(1)(ii)(A) of this section to detect a malfunction before emissions exceed the applicable emissions thresholds. For other fuel metering or control systems, the manufacturer must perform a test at the criteria limit(s). For purposes of fuel system testing as required by this paragraph (1)(3)(ii)(A), the malfunction(s) induced may result in a uniform distribution of fuel and air among the cylinders. Non uniform distribution of fuel and air used to induce a malfunction shall not cause misfire. In conducting the fuel system demonstration tests, the manufacturer may use computer modifications to cause the fuel system to operate at the malfunction limit. To do so, the manufacturer must be able to demonstrate that the computer modifications produce test results equivalent to an induced hardware malfunction.

(B) *Misfire.* The manufacturer must perform a test at the malfunction criteria limit specified in paragraph (h)(2)(ii)(B) of this section.

(C) *EGR system.* The manufacturer must perform a test at each flow limit calibrated to the malfunction criteria

specified in paragraphs (h)(3)(ii)(A) and (h)(3)(ii)(B) of this section.

(D) *Cold start emission reduction strategy.* The manufacturer must perform a test at the malfunction criteria for each component monitored according to paragraph (h)(4)(ii)(A) of this section.

(E) *Secondary air system.* The manufacturer must perform a test at each flow limit calibrated to the malfunction criteria specified in paragraphs (h)(5)(ii)(A) and (h)(5)(ii)(B) of this section.

(F) *Catalyst.* The manufacturer must perform a test using a catalyst system deteriorated to the malfunction criteria specified in paragraph (h)(6)(ii) of this section using methods established by the manufacturer in accordance with paragraph (l)(7)(ii) of this section. The manufacturer must also demonstrate that the OBD system will detect a catalyst system malfunction with the catalyst system at its maximum level of deterioration (i.e., the substrate(s) completely removed from the catalyst container or “empty” can). Emission data are not required for the empty can demonstration.

(G) *Exhaust gas sensor.* The manufacturer must perform a test with all primary exhaust gas sensors used for fuel control simultaneously possessing a response rate deteriorated to the malfunction criteria limit specified in paragraph (h)(8)(ii)(A) of this section. The manufacturer must also perform a test for any other primary or secondary exhaust gas sensor parameter under paragraphs (h)(8)(ii)(A) and (h)(8)(iii)(A) of this section that can cause engine emissions to exceed the applicable emissions thresholds (e.g., shift in air/fuel ratio at which oxygen sensor switches, decreased amplitude). When performing additional test(s), all primary and secondary (if applicable) exhaust gas sensors used for emission control must be operating at the malfunction criteria limit for the applicable parameter only. All other primary and secondary exhaust gas sensor parameters must be operating with normal characteristics.

(H) *VVT system.* The manufacturer must perform a test at each target error limit and slow response limit calibrated to the malfunction criteria

specified in paragraphs (h)(9)(ii)(A) and (h)(9)(ii)(B) of this section. In conducting the VVT system demonstration tests, the manufacturer may use computer modifications to cause the VVT system to operate at the malfunction limit. To do so, the manufacturer must be able to demonstrate that the computer modifications produce test results equivalent to an induced hardware malfunction.

(I) For each of the testing requirements of this paragraph (l)(3)(ii), if the manufacturer has established that only a functional check is required because no failure or deterioration of the specific tested system could cause an engine's emissions to exceed the applicable emissions thresholds, the manufacturer is not required to perform a demonstration test; however the manufacturer is required to provide the data and/or engineering analyses used to determine that only a functional test of the system(s) is required.

(iii) *Required testing for all engines.* (A) Other emission control systems. The manufacturer must conduct demonstration tests for all other emission control components (e.g., hydrocarbon traps, adsorbers) designed and calibrated to a malfunction limit based on an emissions threshold based on the requirements of paragraph (i)(4) of this section.

(B) For each of the testing requirements of paragraph (l)(3)(iii)(A) of this section, if the manufacturer has established that only a functional check is required because no failure or deterioration of the specific tested system could result in an engine's emissions exceeding the applicable emissions thresholds, the manufacturer is not required to perform a demonstration test; however, the manufacturer is required to provide the data and/or engineering analysis used to determine that only a functional test of the system(s) is required.

(iv) The manufacturer may electronically simulate deteriorated components but shall not make any engine control unit modifications when performing demonstration tests unless approved by the Administrator. All equipment necessary to duplicate the demonstration test must be made

available to the Administrator upon request.

(4) *Testing protocol*—(i) *Preconditioning*. The manufacturer must use an applicable cycle for preconditioning test engines prior to conducting each of the emission tests required by paragraph (1)(3) of this section. The manufacturer may perform a single additional preconditioning cycle, identical to the initial one, after a 20-minute hot soak but must demonstrate that such an additional cycle is necessary to stabilize the emissions control system. A practice of requiring a cold soak prior to conducting preconditioning cycles is not permitted.

(ii) *Test sequence*. (A) The manufacturer must set individually each system or component on the test engine at the malfunction criteria limit prior to conducting the applicable preconditioning cycle(s). If a second preconditioning cycle is permitted in accordance with paragraph (1)(4)(i) of this section, the manufacturer may adjust the system or component to be tested before conducting the second preconditioning cycle. The manufacturer shall not replace, modify, or adjust the system or component after the last preconditioning cycle has been completed.

(B) After preconditioning, the test engine must be operated over the applicable cycle to allow for the initial detection of the tested system or component malfunction. This test cycle may be omitted from the testing protocol if it is unnecessary. If required by the monitoring strategy being tested, a cold soak may be performed prior to conducting this test cycle.

(C) The test engine must then be operated over the applicable exhaust emissions test.

(iii) A manufacturer required to test more than one test engine according to paragraph (1)(2)(iii) of this section may use internal calibration sign-off test procedures (e.g., forced cool downs, less frequently calibrated emission analyzers) instead of official test procedures to obtain the emission test data required by this paragraph (1) of this section for all but one of the required test engines. The manufacturer may elect this option if the data from the alternative test procedure are representative of official emissions test

results. A manufacturer using this option is still responsible for meeting the malfunction criteria specified in paragraphs (g) through (i) of this section if and when emissions tests are performed in accordance with official test procedures.

(iv) The manufacturer may request approval to use an alternative testing protocol for demonstration of MIL activation if the engine dynamometer emission test cycle does not allow all of a given monitor's enable conditions to be satisfied. The manufacturer may request the use of an alternative engine dynamometer test cycle or the use of chassis testing to demonstrate proper MIL activation. To do so, the manufacturer must demonstrate the technical necessity for using an alternative test cycle and the degree to which the alternative test cycle demonstrates that in-use operation with the malfunctioning component will result in proper MIL activation.

(5) *Evaluation protocol*. Full OBD engine ratings, as defined by paragraph (o)(1) of this section, shall be evaluated according to the following protocol:

(i) For all tests conducted as required by paragraph (1) of this section, the MIL must activate before the end of the first engine start portion of the applicable test.

(ii) If the MIL activates prior to emissions exceeding the applicable malfunction criteria limits specified in paragraphs (g) through (i), no further demonstration is required. With respect to the misfire monitor demonstration test, if the manufacturer has elected to use the minimum misfire malfunction criteria of one percent as allowed in paragraphs (g)(2)(ii)(B), if applicable, and (h)(2)(ii)(B) of this section, no further demonstration is required provided the MIL activates with engine misfire occurring at the malfunction criteria limit.

(iii) If the MIL does not activate when the system or component is set at its malfunction criteria limit(s), the criteria limit(s) or the OBD system is not acceptable.

(A) Except for testing of the catalyst or DPF system, if the MIL first activates after emissions exceed the applicable malfunction criteria specified in

paragraphs (g) through (i) of this section, the test engine shall be retested with the tested system or component adjusted so that the MIL will activate before emissions exceed the applicable malfunction criteria specified in paragraphs (g) through (i) of this section. If the component cannot be so adjusted because an alternative fuel or emission control strategy is used when a malfunction is detected (e.g., open loop fuel control used after an oxygen sensor malfunction is detected), the test engine shall be retested with the component adjusted to the worst acceptable limit (i.e., the applicable OBD monitor indicates that the component is performing at or slightly better than the malfunction criteria limit). When tested with the component so adjusted, the MIL must not activate during the test and the engine emissions must be below the applicable malfunction criteria specified in paragraphs (g) through (i) of this section.

(B) In testing the catalyst or DPF system, if the MIL first activates after emissions exceed the applicable emissions threshold(s) specified in paragraphs (g) and (h), the tested engine shall be retested with a less deteriorated catalyst or DPF system (i.e., more of the applicable engine out pollutants are converted or trapped). For the OBD system to be approved, testing shall be continued until the MIL activates with emissions below the applicable thresholds of paragraphs (g) and (h) of this section, or the MIL activates with emissions within a range no more than 20 percent below the applicable emissions thresholds and 10 percent or less above those emissions thresholds.

(iv) If an OBD system is determined to be unacceptable by the criteria of this paragraph (1)(5) of this section, the manufacturer may recalibrate and retest the system on the same test engine. In such a case, the manufacturer must confirm, by retesting, that all systems and components that were tested prior to the recalibration and are affected by it still function properly with the recalibrated OBD system.

(6) *Confirmatory testing.* (i) The Administrator may perform confirmatory testing to verify the emission test data submitted by the manufacturer as required by this paragraph (1) of this sec-

tion comply with its requirements and the malfunction criteria set forth in paragraphs (g) through (i) of this section. Such confirmatory testing is limited to the test engine(s) required by paragraph (1)(2) of this section.

(ii) To conduct this confirmatory testing, the Administrator may install appropriately deteriorated or malfunctioning components (or simulate them) in an otherwise properly functioning test engine of an engine rating represented by the demonstration test engine in order to test any of the components or systems required to be tested by paragraph (1) of this section. The manufacturer shall make available, if requested, an engine and all test equipment (e.g., malfunction simulators, deteriorated components) necessary to duplicate the manufacturer's testing. Such a request from the Administrator shall occur within six months of reviewing and approving the demonstration test engine data submitted by the manufacturer for the specific engine rating.

(7) *Catalyst aging*—(i) *Diesel catalysts.* For purposes of determining the catalyst malfunction limits for the monitoring required by paragraphs (g)(5)(ii)(A), (g)(5)(ii)(B), and (g)(6)(ii)(A) of this section, where those catalysts are monitored individually, the manufacturer must use a catalyst deteriorated to the malfunction criteria using methods established by the manufacturer to represent real world catalyst deterioration under normal and malfunctioning engine operating conditions. For purposes of determining the catalyst malfunction limits for the monitoring required by paragraphs (g)(5)(ii)(A), (g)(5)(ii)(B), and (g)(6)(ii)(A) of this section, where those catalysts are monitored in combination with other catalysts, the manufacturer must submit their catalyst system aging and monitoring plan to the Administrator as part of their certification documentation package. The plan must include the description, emission control purpose, and location of each component, the monitoring strategy for each component and/or combination of components, and the method for determining the applicable malfunction criteria including the deterioration/aging process.

(ii) *Gasoline catalysts.* For the purposes of determining the catalyst system malfunction criteria in paragraph (h)(6)(ii) of this section, the manufacturer must use a catalyst system deteriorated to the malfunction criteria using methods established by the manufacturer to represent real world catalyst deterioration under normal and malfunctioning operating conditions. The malfunction criteria must be established by using a catalyst system with all monitored and unmonitored (downstream of the sensor utilized for catalyst monitoring) catalysts simultaneously deteriorated to the malfunction criteria except for those engines that use fuel shutoff to prevent over-fueling during engine misfire conditions. For such engines, the malfunction criteria must be established by using a catalyst system with all monitored catalysts simultaneously deteriorated to the malfunction criteria while unmonitored catalysts shall be deteriorated to the end of the engine's useful life.

(m) *Certification documentation requirements.* (1) When submitting an application for certification of an engine, the manufacturer must submit the following documentation. If any of the items listed here are standardized for all of the manufacturer's engines, the manufacturer may, for each model year, submit one set of documents covering the standardized items for all of its engines.

(i) For the required documentation that is not standardized across all engines, the manufacturer may be allowed to submit documentation for certification from one engine that is representative of other engines. All such engines shall be considered to be part of an OBD certification documentation group. To represent the OBD group, the chosen engine must be certified to the most stringent emissions standards and OBD monitoring requirements and cover all of the emissions control devices for the engines in the group and covered by the submitted documentation. Such OBD groups must be approved in advance of certification.

(ii) Upon approval, one or more of the documentation requirements of this paragraph (m) of this section may be waived or modified if the information

required is redundant or unnecessarily burdensome to generate.

(iii) To the extent possible, the certification documentation must use SAE J1930 (as specified in paragraph (k)(1) of this section) or SAE J2403 (as specified in paragraph (k)(1) of this section) terms, abbreviations, and acronyms as specified in paragraph (k)(1) of this section.

(2) Unless otherwise specified, the following information must be submitted as part of the certification application and prior to receiving a certificate.

(i) A description of the functional operation of the OBD system including a complete written description for each monitoring strategy that outlines every step in the decision-making process of the monitor. Algorithms, diagrams, samples of data, and/or other graphical representations of the monitoring strategy shall be included where necessary to adequately describe the information.

(ii) A table including the following information for each monitored component or system (either computer-sensed or computer-controlled) of the emissions control system:

(A) Corresponding diagnostic trouble code.

(B) Monitoring method or procedure for malfunction detection.

(C) Primary malfunction detection parameter and its type of output signal.

(D) Malfunction criteria limits used to evaluate output signal of primary parameter.

(E) Other monitored secondary parameters and conditions (in engineering units) necessary for malfunction detection.

(F) Monitoring time length and frequency of monitoring events.

(G) Criteria for storing a diagnostic trouble code.

(H) Criteria for activating a malfunction indicator light.

(I) Criteria used for determining out-of-range values and input component rationality checks.

(iii) Whenever possible, the table required by paragraph (m)(2)(ii) of this section shall use the following engineering units:

(A) Degrees Celsius for all temperature criteria.

(B) KiloPascals (KPa) for all pressure criteria related to manifold or atmospheric pressure.

(C) Grams (g) for all intake air mass criteria.

(D) Pascals (Pa) for all pressure criteria related to evaporative system vapor pressure.

(E) Miles per hour (mph) for all vehicle speed criteria.

(F) Relative percent (%) for all relative throttle position criteria (as defined in SAE J1979 or SAE J1939 (both as specified in paragraph (k)(1) of this section)).

(G) Voltage (V) for all absolute throttle position criteria (as defined in SAE J1979 or SAE J1939 (both as specified in paragraph (k)(1) of this section)).

(H) Per crankshaft revolution (/rev) for all changes per ignition event based criteria (e.g., g/rev instead of g/stroke or g/firing).

(I) Per second (/sec) for all changes per time based criteria (e.g., g/sec).

(J) Percent of nominal tank volume (%) for all fuel tank level criteria.

(iv) A logic flowchart describing the step-by-step evaluation of the enable criteria and malfunction criteria for each monitored emission related component or system.

(v) Emissions test data, a description of the testing sequence (e.g., the number and types of preconditioning cycles), approximate time (in seconds) of MIL activation during the test, diagnostic trouble code(s) and freeze frame information stored at the time of detection, corresponding test results (e.g. SAE J1979 (as specified in paragraph (k)(1) of this section) Mode/Service \$06, SAE J1939 (as specified in paragraph (k)(1) of this section) Diagnostic Message 8 (DM8)) stored during the test, and a description of the modified or deteriorated components used for malfunction simulation with respect to the demonstration tests specified in paragraph (l) of this section. The freeze frame data are not required for engines termed "Extrapolated OBD" engines.

(vi) For gasoline engines, data supporting the misfire monitor, including:

(A) The established percentage of misfire that can be tolerated without damaging the catalyst over the full

range of engine speed and load conditions.

(B) Data demonstrating the probability of detection of misfire events by the misfire monitoring system over the full engine speed and load operating range for the following misfire patterns: random cylinders misfiring at the malfunction criteria established in paragraph (h)(2)(ii)(B) of this section, one cylinder continuously misfiring, and paired cylinders continuously misfiring.

(C) Data identifying all disablement of misfire monitoring that occurs during the FTP. For every disablement that occurs during the cycles, the data shall identify: when the disablement occurred relative to the driver's trace, the number of engine revolutions during which each disablement was present, and which disable condition documented in the certification application caused the disablement.

(D) Manufacturers are not required to use the durability demonstration engine to collect the misfire data required by paragraph (m)(2)(vi) of this section.

(vii) Data supporting the limit for the time between engine starting and attaining the designated heating temperature for after-start heated catalyst systems.

(viii) Data supporting the criteria used to detect a malfunction of the fuel system, EGR system, boost pressure control system, catalyst, NO<sub>x</sub> adsorber, DPF, cold start emission reduction strategy, secondary air, evaporative system, VVT system, exhaust gas sensors, and other emission controls that causes emissions to exceed the applicable malfunction criteria specified in paragraphs (g) through (i) of this section. For diesel engine monitors required by paragraphs (g) and (i) of this section that are required to indicate a malfunction before emissions exceed an emission threshold based on any applicable standard (e.g., 2.5 times any of the applicable standards), the test cycle and standard determined by the manufacturer to be the most stringent for each applicable monitor in accordance with paragraph (f)(1) of this section.

(ix) A list of all electronic powertrain input and output signals (including

those not monitored by the OBD system) that identifies which signals are monitored by the OBD system. For input and output signals that are monitored as comprehensive components, the listing shall also identify the specific diagnostic trouble code for each malfunction criteria (e.g., out-of-range low, out-of-range high, open circuit, rationality low, rationality high).

(x) A written description of all parameters and conditions necessary to begin closed-loop/feedback control of emission control systems (e.g., fuel system, boost pressure, EGR flow, SCR reductant delivery, DPF regeneration, fuel system pressure).

(xi) A written identification of the communication protocol utilized by each engine for communication with a scan tool (model years 2010 through 2012) or an SAE J1978 or SAE J1939 (both as specified in paragraph (k)(1) of this section) scan tool (model years 2013 and later).

(xii) For model years 2013 and later, a pictorial representation or written description of the diagnostic connector location including any covers or labels.

(xiii) A written description of the method used by the manufacturer to meet the requirements of paragraph (i)(2) of this section (crankcase ventilation system monitoring) including diagrams or pictures of valve and/or hose connections.

(xiv) Build specifications provided to engine purchasers or chassis manufacturers detailing all specifications or limitations imposed on the engine purchaser relevant to OBD requirements or emissions compliance (e.g., cooling system heat rejection rates, allowable MIL locations, connector location specifications). A description of the method or copies of agreements used to ensure engine purchasers or chassis manufacturers will comply with the OBD and emissions relevant build specifications (e.g., signed agreements, required audit/evaluation procedures).

(xv) Any other information determined by the Administrator to be necessary to demonstrate compliance with the requirements of this section.

(3) In addition to the documentation required by paragraphs (m)(1) and (m)(2) of this section, a manufacturer making use of paragraph (a)(5) of this

section must submit the following information with their application for certification.

(i) A detailed description of how the OBD system meets the intent of § 86.010-18.

(ii) A detailed description of why the manufacturer has chosen not to design the OBD system to meet the requirements of § 86.010-18 and has instead designed the OBD system to meet the applicable California OBD requirements.

(iii) A detailed description of any deficiencies granted by the California staff and any concerns raised by California staff. A copy of a California Executive Order alone will not be considered acceptable toward meeting this requirement. This description shall also include, to the extent feasible, a plan with timelines for resolving deficiencies and/or concerns.

(n) *Deficiencies.* (1) Upon application by the manufacturer, the Administrator may accept an OBD system as compliant even though specific requirements are not fully met. Such compliances without meeting specific requirements, or deficiencies, will be granted only if compliance is infeasible or unreasonable considering such factors as, but not limited to: Technical feasibility of the given monitor and lead time and production cycles including phase-in or phase-out of engines or vehicle designs and programmed upgrades of computers. Unmet requirements shall not be carried over from the previous model year except where unreasonable hardware or software modifications are necessary to correct the deficiency, and the manufacturer has demonstrated an acceptable level of effort toward compliance as determined by the Administrator. Furthermore, EPA will not accept any deficiency requests that include the complete lack of a major diagnostic monitor ("major" diagnostic monitors being those for exhaust aftertreatment devices, oxygen sensor, air-fuel ratio sensor, NO<sub>x</sub> sensor, engine misfire, evaporative leaks, and diesel EGR, if equipped), with the possible exception of the special provisions for alternative fueled engines. For alternative fueled heavy-duty engines (e.g., natural gas, liquefied petroleum gas, methanol, ethanol), manufacturers may request the



Administrator to waive specific monitoring requirements of this section for which monitoring may not be reliable with respect to the use of the alternative fuel. At a minimum, alternative fuel engines must be equipped with an OBD system meeting OBD requirements to the extent feasible as approved by the Administrator.

(2) In the event the manufacturer seeks to carry-over a deficiency from a past model year to the current model year, the manufacturer must re-apply for approval to do so. In considering the request to carry-over a deficiency, the Administrator shall consider the manufacturer's progress towards correcting the deficiency. The Administrator may not allow manufacturers to carry over monitoring system deficiencies for more than two model years unless it can be demonstrated that substantial engine hardware modifications and additional lead time beyond two years are necessary to correct the deficiency.

(3) A deficiency shall not be granted retroactively (i.e., after the engine has been certified).

(o) *Implementation schedule.* Except as specifically provided for in this paragraph (o) for small volume manufacturers and alternative fueled engines, the requirements of this section must be met according to the following provisions:

(1) *For model years 2010 through 2012—*  
(i) *Full OBD.* The manufacturer must implement an OBD system meeting the applicable requirements of § 86.010-18 on one engine rating within one engine family of the manufacturer's product line. This "Full OBD" rating will be known as the "OBD parent" rating. The OBD parent rating must be chosen, unless otherwise approved by the Administrator, as the rating having the highest weighted projected U.S. sales within the engine family having the highest weighted projected U.S. sales, with U.S. sales being weighted by the useful life of the engine rating.

(ii) *Extrapolated OBD.* For all other engine ratings within the engine family from which the OBD parent rating has been selected, the manufacturer must implement an OBD system meeting the applicable requirements of § 86.010-18 except that the OBD system

is not required to detect a malfunction prior to exceeding the emission thresholds shown in Table 1 of paragraph (g) and Table 2 of paragraph (h) of this section. These "Extrapolated OBD" engines will be known as the "OBD child" ratings. On these OBD child ratings, rather than detecting a malfunction prior to exceeding the emission thresholds, the manufacturer must submit a plan for Administrator review and approval that details the engineering evaluation the manufacturer will use to establish the malfunction criteria for the OBD child ratings. The plan must demonstrate both the use of good engineering judgment in establishing the malfunction criteria, and robust detection of malfunctions, including consideration of differences of base engine, calibration, emission control components, and emission control strategies.

(iii) Engine families other than those from which the parent and child ratings have been selected, are not subject to the requirements of this section.

(iv) Small volume manufacturers, as defined in § 86.094-14(b)(1) and (2) and as determined using 2010 model year sales, are exempt from the requirements of this § 86.010-18, unless model year 2011 or model year 2012 sales exceed 20,000 units.

(v) Engines certified as alternative fueled engines are exempt from the requirements of this § 86.010-18.

(2) *For model years 2013 through 2015—*  
(i) *OBD groups.* The manufacturer shall define one or more OBD groups to cover all engine ratings in all engine families. The manufacturer must submit a grouping plan for Administrator review and approval detailing the OBD groups and the engine families and engine ratings within each group for a given model year.

(ii) *Full OBD.* (A) For all model year 2010 through 2012 "Full OBD" and "Extrapolated OBD" engine ratings, the manufacturer must implement an OBD system meeting the applicable requirements of this section.

(B) On one engine rating within each of the manufacturer's OBD groups, the manufacturer must implement an OBD system meeting the applicable requirements of this section. These "Full OBD" ratings will be known as the

“OBD parent” ratings. The OBD parent rating for each OBD group shall be chosen, unless otherwise approved by the Administrator, as the rating having the highest weighted projected U.S. sales within the OBD group, with U.S. sales being weighted by the useful life of the engine rating.

(iii) *Extrapolated OBD*. For all other engine ratings within each OBD group, the manufacturer must implement an OBD system meeting the requirements of this section except that the OBD system is not required to detect a malfunction prior to exceeding the emission thresholds shown in Table 1 of paragraph (g) and Table 2 of paragraph (h) of this section. These extrapolated OBD engines will be known as the “OBD child” ratings. On these OBD child ratings, rather than detecting a malfunction prior to exceeding the emission thresholds, the manufacturer must submit a plan for Administrator review and approval that details the engineering evaluation the manufacturer will use to establish the malfunction criteria for the OBD child ratings. The plan must demonstrate both the use of good engineering judgment in establishing the malfunction criteria, and robust detection of malfunctions, including consideration of differences of base engine, calibration, emission control components, and emission control strategies.

(iv) Engines certified as alternative fueled engines shall meet, to the extent feasible, the requirements specified in paragraph (i)(3) of this § 86.010-18. Additionally, such engines shall monitor the NO<sub>x</sub> aftertreatment system on engines so equipped and detect a malfunction if:

(A) The NO<sub>x</sub> aftertreatment system has no detectable amount of NO<sub>x</sub> aftertreatment capability (i.e., NO<sub>x</sub> catalyst conversion or NO<sub>x</sub> adsorption).

(B) The NO<sub>x</sub> aftertreatment substrate is completely destroyed, removed, or missing.

(C) The NO<sub>x</sub> aftertreatment assembly is replaced with a straight pipe.

(3) *For model years 2016 through 2018—*  
(i) *OBD groups*. The manufacturer shall define one or more OBD groups to cover all engine ratings in all engine families. The manufacturer must sub-

mit a grouping plan for Administrator review and approval detailing the OBD groups and the engine families and engine ratings within each group for a given model year.

(ii) *Full OBD*. The manufacturer must implement an OBD system meeting the applicable requirements of this section on all engine ratings in all engine families.

(iii) Engines certified as alternative fueled engines shall meet, to the extent feasible, the requirements specified in paragraph (i)(3) of this § 86.010-18. Additionally, such engines shall monitor the NO<sub>x</sub> aftertreatment system on engines so equipped and detect a malfunction if:

(A) The NO<sub>x</sub> aftertreatment system has no detectable amount of NO<sub>x</sub> aftertreatment capability (i.e., NO<sub>x</sub> catalyst conversion or NO<sub>x</sub> adsorption).

(B) The NO<sub>x</sub> aftertreatment substrate is completely destroyed, removed, or missing.

(C) The NO<sub>x</sub> aftertreatment assembly is replaced with a straight pipe.

(4) *For model years 2019 and later*. (i) The manufacturer must implement an OBD system meeting the applicable requirements of § 86.010-18 on all engines.

(p) *In-use compliance standards*. For monitors required to indicate a malfunction before emissions exceed a certain emission threshold (e.g., 2.5 times any of the applicable standards):

(1) *For model years 2010 through 2012*.

(i) On the full OBD rating (i.e., the parent rating) as defined in paragraph (o)(1) of this section, separate in-use emissions thresholds shall apply. These thresholds are determined by doubling the applicable thresholds as shown in Table 1 of paragraph (g) and Table 2 of paragraph (h) of this section. The resultant thresholds apply only in-use and do not apply for certification or selective enforcement auditing.

(ii) The extrapolated OBD ratings (i.e., the child ratings) as defined in paragraph (o)(1) of this section shall not be evaluated against emissions levels for purposes of OBD compliance in-use.

(iii) Only the test cycle and standard determined and identified by the manufacturer at the time of certification in accordance with paragraph (f) of this

section as the most stringent shall be used for the purpose of determining OBD system noncompliance in-use.

(iv) An OBD system shall not be considered noncompliant solely due to a failure or deterioration mode of a monitored component or system that could not have been reasonably foreseen to occur by the manufacturer.

(2) *For model years 2013 through 2015.*

(i) On the full OBD ratings as defined in paragraph (o)(2) of this section, separate in-use emissions thresholds shall apply. These thresholds are determined by doubling the applicable thresholds as shown in Table 1 of paragraph (g) and Table 2 of paragraph (h) of this section. The resultant thresholds apply only in-use and do not apply for certification or selective enforcement auditing.

(ii) The extrapolated OBD ratings as defined in paragraph (o)(2) of this section shall not be evaluated against emissions levels for purposes of OBD compliance in-use.

(iii) Only the test cycle and standard determined and identified by the manufacturer at the time of certification in accordance with paragraph (f) of this section as the most stringent shall be used for the purpose of determining OBD system noncompliance in-use.

(iv) For monitors subject to meeting the minimum in-use monitor performance ratio of 0.100 in paragraph (d)(1)(ii), the OBD system shall not be considered noncompliant unless a representative sample indicates the in-use ratio is below 0.050.

(v) An OBD system shall not be considered noncompliant solely due to a failure or deterioration mode of a monitored component or system that could not have been reasonably foreseen to occur by the manufacturer.

(3) *For model years 2016 through 2018.*

(i) On the engine ratings tested according to (1)(2)(iii) of this section, the certification emissions thresholds shall apply in-use.

(ii) On the manufacturer's remaining engine ratings, separate in-use emissions thresholds shall apply. These thresholds are determined by doubling the applicable thresholds as shown in Table 1 of paragraph (g) and Table 2 of paragraph (h) of this section. The resultant thresholds apply only in-use

and do not apply for certification or selective enforcement auditing.

(iii) An OBD system shall not be considered noncompliant solely due to a failure or deterioration mode of a monitored component or system that could not have been reasonably foreseen to occur by the manufacturer.

(4) *For model years 2019 and later.* (i)

On all engine ratings, the certification emissions thresholds shall apply in-use.

(ii) An OBD system shall not be considered noncompliant solely due to a failure or deterioration mode of a monitored component or system that could not have been reasonably foreseen to occur by the manufacturer.

(q) *Optional phase-in for hybrid vehicles.* This paragraph (q) applies for model year 2013 through 2015 engines when used with hybrid powertrain systems. It also applies for model year 2016 engines used with hybrid powertrain systems that were offered for sale prior to January 1, 2013, as specified in paragraph (q)(4) of this section. Manufacturers choosing to use the provisions of this paragraph (q) must submit an annual pre-compliance report to EPA for model years 2013 and later, as specified in paragraph (q)(5) of this section. Note that all hybrid powertrain systems must be fully compliant with the OBD requirements of this section no later than model year 2017.

(1) If an engine-hybrid system has been certified by the California Air Resources Board with respect to its OBD requirements and it effectively meets the full OBD requirements of this section, all equivalent systems must meet those same requirements and may not be certified under this paragraph (q). For purposes of this paragraph (q)(1), an engine-hybrid system is considered to be equivalent to the certified system if it uses the same basic design (*e.g.* displacement) for the engine and primary hybrid components (see paragraph (q)(4) of this section). Equivalent systems may have minor hardware or calibration differences.

(2) As of 2013, if an engine-hybrid system has not been certified to meet the full OBD requirements of this section, it must comply with the following requirements:

(i) The engine in its installed configuration must meet the EMD and EMD+ requirements in 13 CCR §1971.1(d)(7.1.4) of the California Code of Regulations. For purposes of this paragraph (q), a given EMD requirement is deemed to be met if the engine's OBD system addresses the same function. This allowance does not apply for OBD monitors or diagnostics that have been modified under paragraph (q)(2)(ii) of this section.

(ii) The engine-hybrid system must maintain existing OBD capability for engines where the same or equivalent engine has been OBD certified. An equivalent engine is one produced by the same engine manufacturer with the same fundamental design, but that may have hardware or calibration differences that do not impact OBD functionality, such as slightly different displacement, rated power, or fuel system. (Note that engines with the same fundamental design will be presumed to be equivalent unless the manufacturer demonstrates that the differences effectively preclude applying equivalent OBD systems.) Though the OBD capability must be maintained, it does not have to meet detection thresholds (as described in Tables 1 and 2 of this section) and in-use performance frequency requirements (as described in paragraph (d) of this section). A manufacturer may modify detection thresholds to prevent false detection, and must indicate all deviations from the originally certified package with engineering justification in the certification documentation.

(iii) This paragraph (q)(2)(iii) applies for derivatives of hybrid powertrain system designs that were offered for sale prior to January 1, 2013. Until these systems achieve full OBD certification, they must at a minimum maintain all fault-detection and diagnostic capability included on similar systems offered for sale prior to 2013. Manufacturers choosing to use the provisions of this paragraph (q)(2) must keep copies of the service manuals (and similar documents) for these previous model years to show the technical description of the system's fault detection and diagnostic capabilities.

(iv) You must submit an annual pre-compliance report to EPA for model

years 2013 and later, as specified in paragraph (q)(5) of this section.

(3) Engine-hybrid systems may be certified to the requirements of paragraph (q)(2) of this section by the engine manufacturer, the hybrid system manufacturer, or the vehicle manufacturer. If engine manufacturers certify the engine hybrid system, they must provide detailed installation instructions. Where the engine manufacturer does not specifically certify its engines for use in hybrid vehicles under this paragraph (q), the hybrid system manufacturer and vehicle manufacturer must install the engine to conform to the requirements of this section (*i.e.*, full OBD) or recertify under paragraph (q)(2) of this section.

(4) The provisions of this paragraph (q) apply for model year 2016 engines where you demonstrate that the hybrid powertrain system used is a derivative of a design that was offered for sale prior to January 1, 2013. In this case, you may ask us to consider the original system and the later system to be the same model for purposes of this paragraph (q), unless the systems are fundamentally different. In determining whether such systems are derivative or fundamentally different, we will consider factors such as the similarity of the following:

(i) Transmissions.

(ii) Hybrid machines (where "hybrid machine" means any system that is the part of a hybrid vehicle system that captures energy from and returns energy to the powertrain).

(iii) Hybrid architecture (such as parallel or series).

(iv) Motor/generator size, controller/CPU (memory or inputs/outputs), control algorithm, and batteries. This paragraph (q)(4)(iv) applies only if all of these are modified simultaneously.

(5) Manufacturers choosing to use the provisions of this paragraph (q) must submit an annual pre-compliance report to EPA for model years 2013 and later. Engine manufacturers must submit this report with their engine certification information. Hybrid manufacturers that are not certifying the engine-hybrid system must submit their report by June 1 of the model year, or at the time of certification if

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they choose to certify. Include the following in the report:

(i) A description of the manufacturer's product plans and of the engine-hybrid systems being certified.

(ii) A description of activities undertaken and progress made by the manufacturer towards achieving full OBD certification, including monitoring, diagnostics, and standardization.

(iii) For model year 2016 engines, a description of your basis for applying the provision of this paragraph (q) to the engines.

[74 FR 8369, Feb. 24, 2009, as amended at 76 FR 57374, Sept. 15, 2011]

EFFECTIVE DATE NOTE: At 78 FR 36388, June 17, 2013, § 86.010–18 was amended by adding paragraph (q)(6), effective Aug. 16, 2013. For the convenience of the user, the added text is set forth as follows:

### § 86.010–18 On-board Diagnostics for engines used in applications greater than 14,000 pounds GVWR.

\* \* \* \* \*

(q) \* \* \*

(6) Manufacturers that modify the engine's diagnostic system from the approved configuration to be compatible with a hybrid powertrain system under this paragraph (q) must add the following compliance statement to the ECI label: "for use in hybrid applications only".

### § 86.010–38 Maintenance instructions.

(a) The manufacturer shall furnish or cause to be furnished to the purchaser of each new motor vehicle (or motor vehicle engine) subject to the standards prescribed in § 86.099–8, § 86.004–9, § 86.004–10, or § 86.004–11, as applicable, written instructions for the proper maintenance and use of the vehicle (or engine), by the purchaser consistent with the provisions of § 86.004–25, which establishes what scheduled maintenance the Administrator approves as being reasonable and necessary.

(1) The maintenance instructions required by this section shall be in clear, and to the extent practicable, nontechnical language.

(2) The maintenance instructions required by this section shall contain a general description of the documentation which the manufacturer will require from the ultimate purchaser or

any subsequent purchaser as evidence of compliance with the instructions.

(b) Instructions provided to purchasers under paragraph (a) of this section shall specify the performance of all scheduled maintenance performed by the manufacturer on certification durability vehicles and, in cases where the manufacturer performs less maintenance on certification durability vehicles than the allowed limit, may specify the performance of any scheduled maintenance allowed under § 86.004–25.

(c) Scheduled emission-related maintenance in addition to that performed under § 86.004–25(b) may only be recommended to offset the effects of abnormal in-use operating conditions, except as provided in paragraph (d) of this section. The manufacturer shall be required to demonstrate, subject to the approval of the Administrator, that such maintenance is reasonable and technologically necessary to assure the proper functioning of the emission control system. Such additional recommended maintenance shall be clearly differentiated, in a form approved by the Administrator, from that approved under § 86.004–25(b).

(d) Inspections of emission-related parts or systems with instructions to replace, repair, clean, or adjust the parts or systems if necessary, are not considered to be items of scheduled maintenance which insure the proper functioning of the emission control system. Such inspections, and any recommended maintenance beyond that approved by the Administrator as reasonable and necessary under paragraphs (a), (b), and (c) of this section, may be included in the written instructions furnished to vehicle owners under paragraph (a) of this section: Provided, That such instructions clearly state, in a form approved by the Administrator, that the owner need not perform such inspections or recommended maintenance in order to maintain the emissions defect and emissions performance warranty or manufacturer recall liability.

(e) The manufacturer may choose to include in such instructions an explanation of any distinction between the useful life specified on the label, and